16 OCTOBER 1959

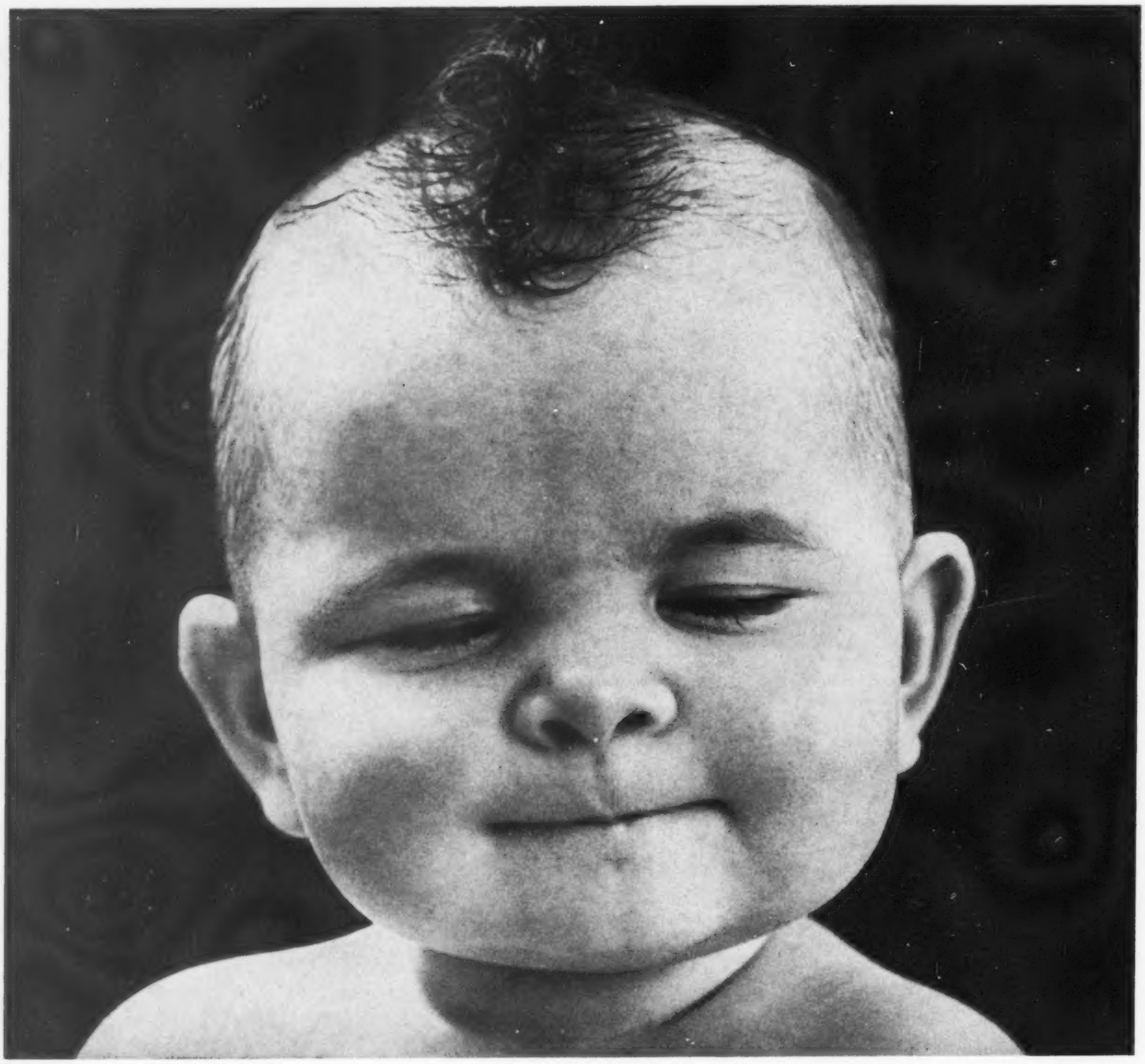
INSTITUTE OF METALS: AUTUMN MEETING

METAL INDUSTRY

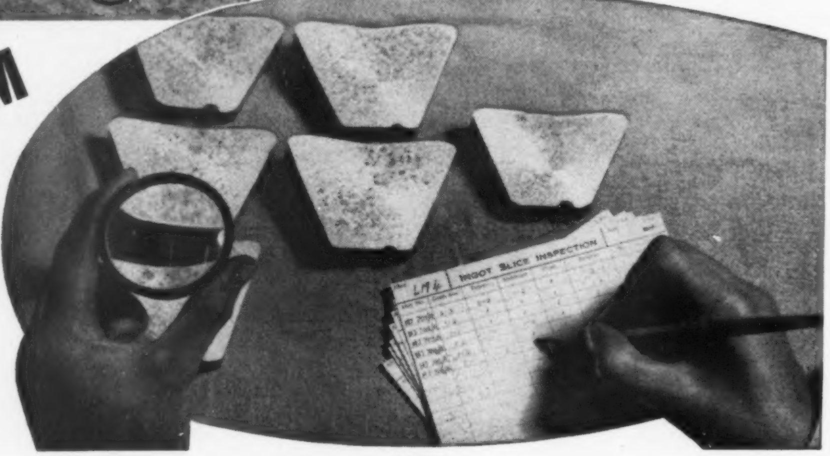
THE JOURNAL OF NON-FERROUS METALS

VOL. 95 No. 10

ONE SHILLING



UNIFORM QUALITY...



Intensive Research and Quality Control
ensure that you can depend on the uniformity of

Unceasing research and strict quality control, at all stages of production, ensures that Intal Light Alloy Ingots can always be depended upon. The quality never varies. With over a quarter of a century's experience and progress, Intal maintain all the newest techniques in scientific inspection, and make use of the most advanced instrumentation in ensuring that the Intal high standard of quality is **consistently maintained.**

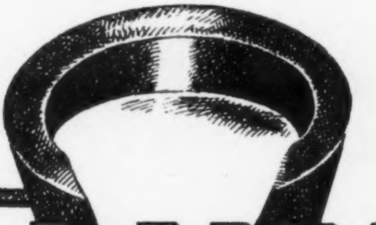
INTAL

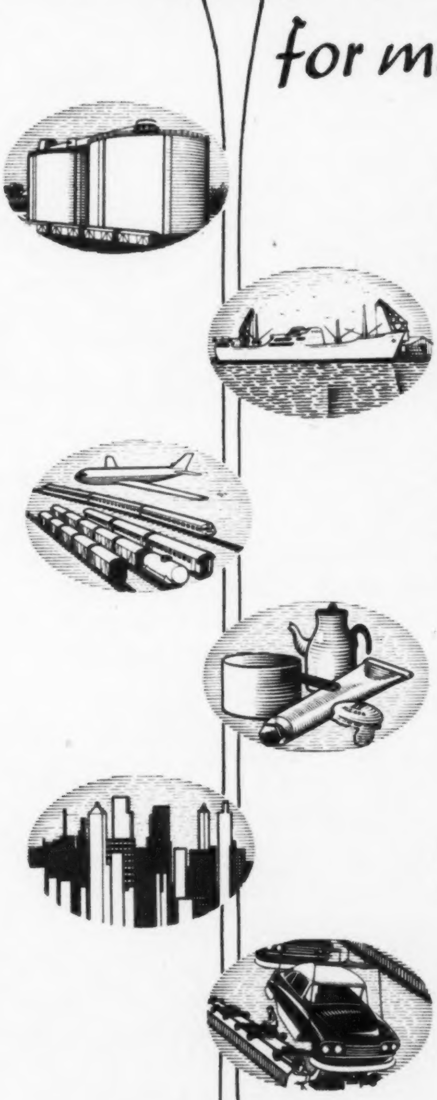
Light Alloy Ingots

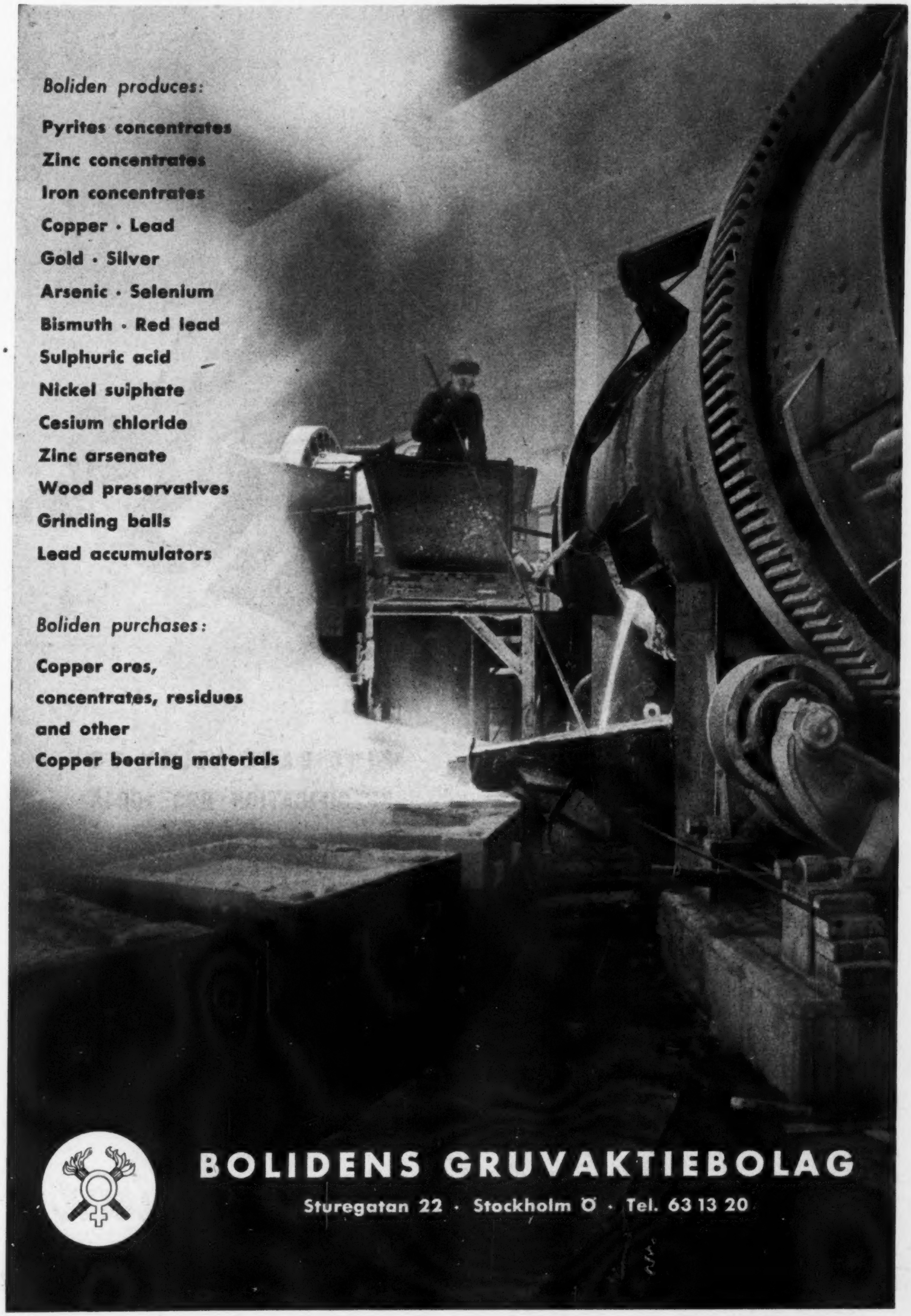
These illustrations are taken from the latest Intal booklet, giving much interesting information on alloy ingot manufacture. We shall be pleased to post a copy to executives on request.

INTERNATIONAL ALLOYS LTD

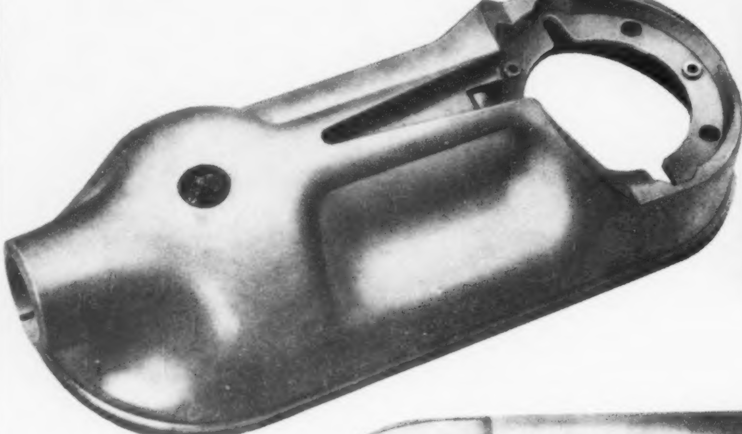
HAYDON HILL, AYLESBURY, BUCKS. Telephone: Aylesbury 4242. Telex. 15/520 Cables: Intalloyd, Aylesbury

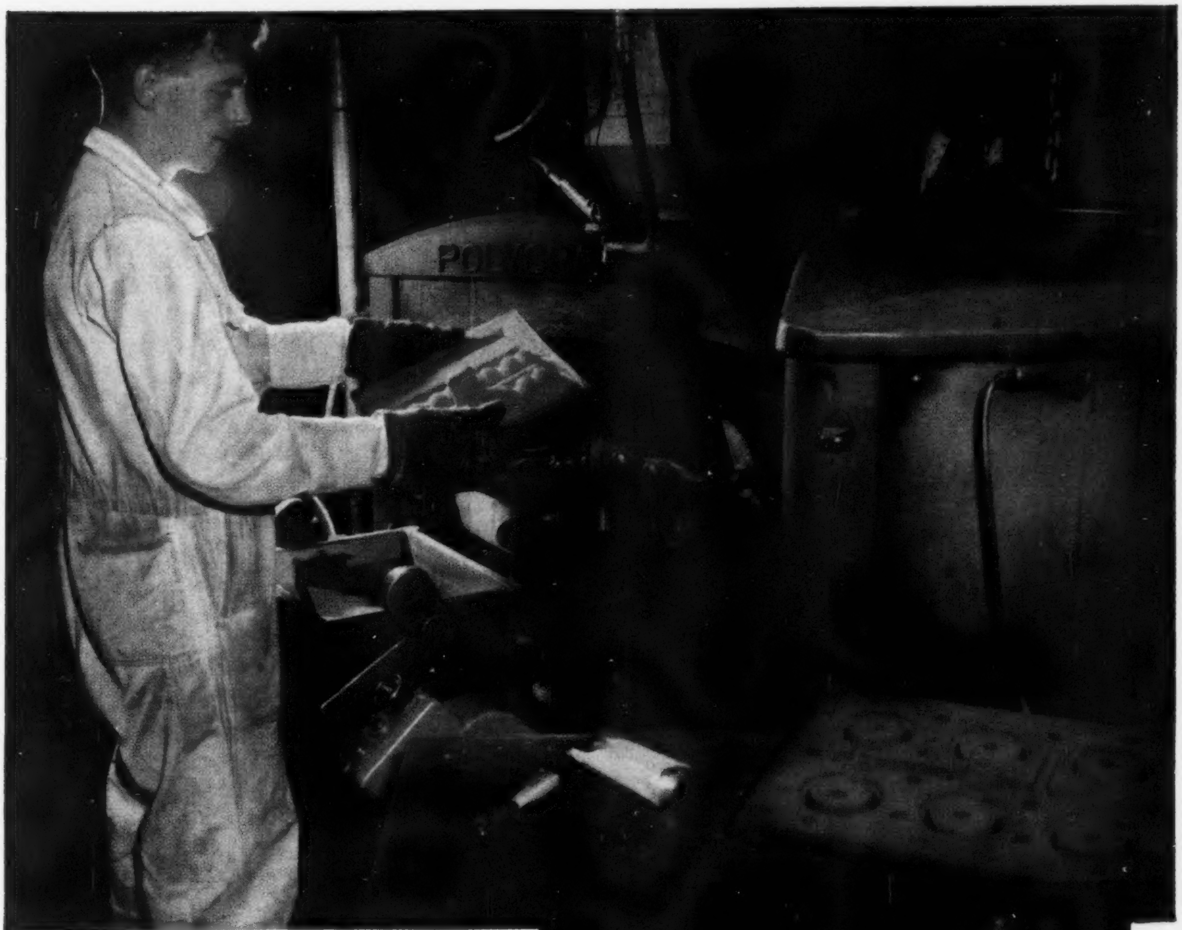


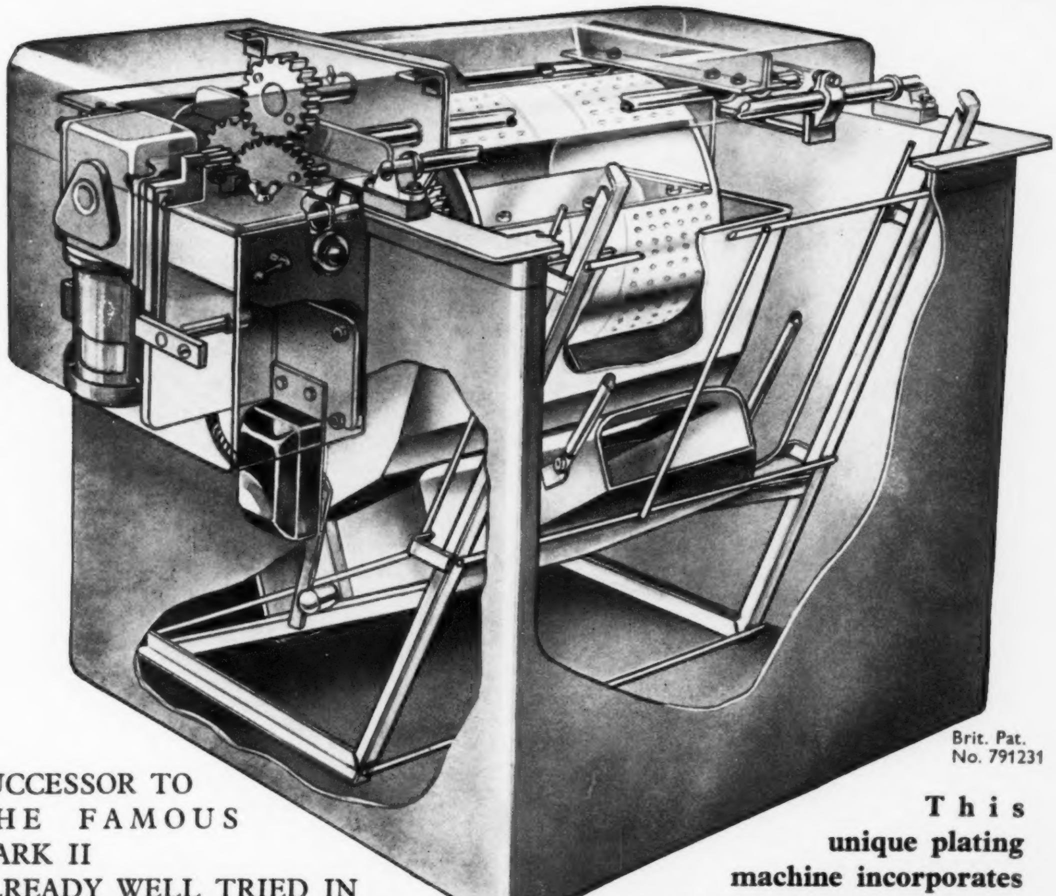


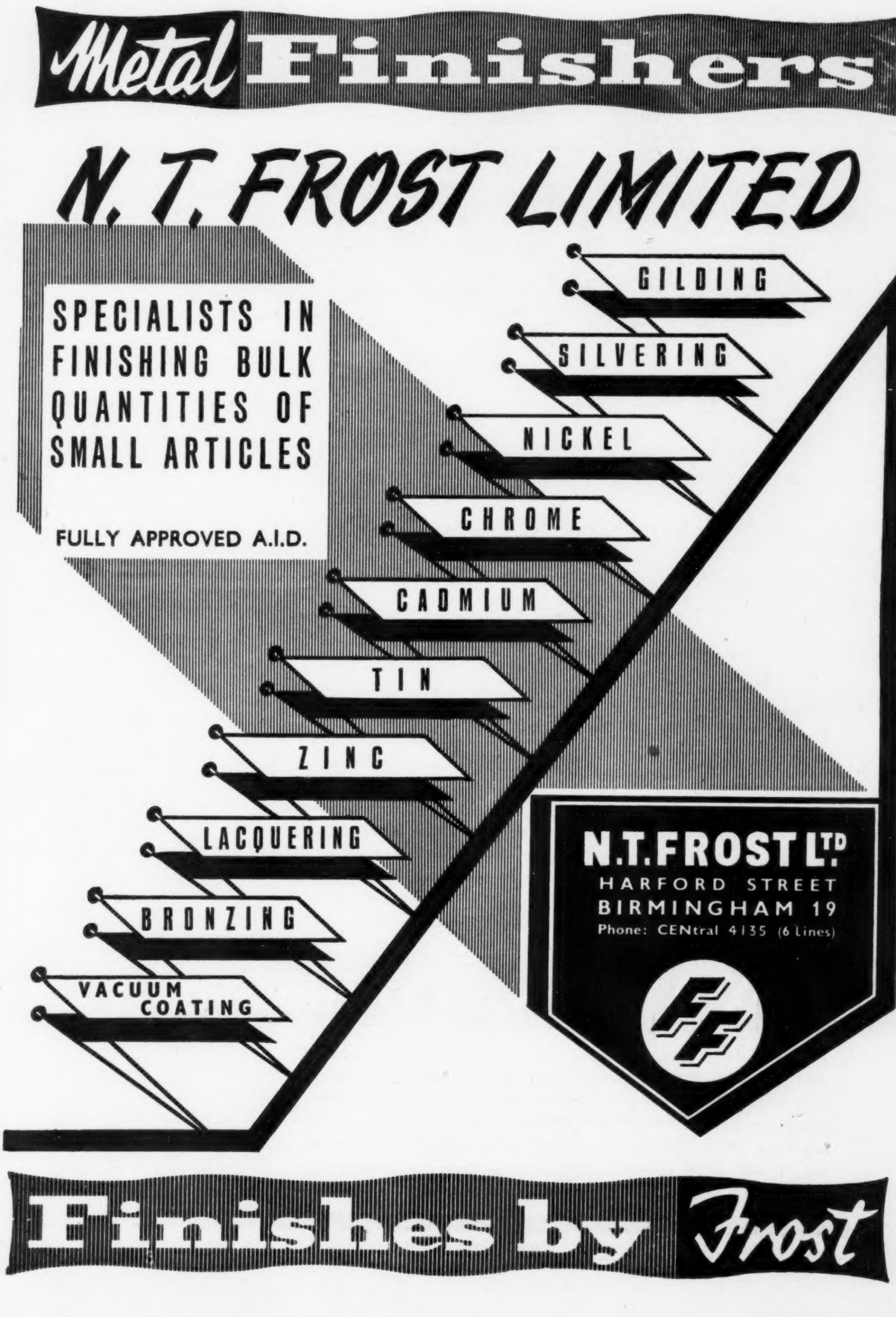

Boliden produces:
Pyrites concentrates
Zinc concentrates
Iron concentrates
Copper · Lead
Gold · Silver
Arsenic · Selenium
Bismuth · Red lead
Sulphuric acid
Nickel sulphate
Cesium chloride
Zinc arsenate
Wood preservatives
Grinding balls
Lead accumulators
Boliden purchases:
Copper ores,
concentrates, residues
and other
Copper bearing materials
BOLIDENS GRUVAKTIEBOLAG
Sturegatan 22 · Stockholm Ö · Tel. 63 13 20

A•






Brit. Pat.
No. 791231


Metal Finishers
N. T. FROST LIMITED
SPECIALISTS IN FINISHING BULK QUANTITIES OF SMALL ARTICLES
FULLY APPROVED A.I.D.
GILDING
SILVERING
NICKEL
CHROME
CADMIUM
TIN
ZINC
LACQUERING
BRONZING
VACUUM COATING
N.T.FROST LTD
HARFORD STREET
BIRMINGHAM 19
Phone: CENtral 4135 (6 Lines)
Finishes by Frost

GUNMETAL,
PHOSPHOR BRONZE,
BRASS,
ALUMINIUM BRONZE,
MANGANESE BRONZE,
REFINED LEAD AND
ALUMINIUM ALLOYS

Also:
ELECTROLYTIC COPPER
CATHODES,
SPELTER PLATES AND
PHOSPHOR COPPER

For over 50 years

John Allan have been making Non-Ferrous Alloy Ingots for British industry. Throughout this time our aim has been to produce metals in ingot form of a quality, consistency and metallurgical accuracy always a little in advance of accepted standards.

When you specify John Allan Ingots you get metal with a background of tradition, of service, and, above all, of metallurgical experience.

JOHN ALLAN & Co. (Glenpark) Ltd.

ESTABLISHED 1898

GLASGOW WORKS, GLENPARK ROAD, E.1. Tel: BRIDGETON 3841 (5 lines) 'Grams: "ALLMETALS, GLASGOW."

BIRMINGHAM WORKS: FREETH STREET, OLDBURY. Tel: BROADWELL 1325 (5 lines) 'Grams: "ALLMETALS, OLDBURY."

LONDON: THOMAS ROAD, E.14. Tel: EASt 5411. 'Grams: "ALLOYS, LONDON, E.14"

ALSO AT NEWCASTLE-ON-TYNE

A MEMBER OF THE METAL INDUSTRIES GROUP

Aluminium Cable Sheathing Press sheathing a power cable.

17 SCHLOEMANN Aluminium Cable Sheathing Presses under Construction or in Operation

The first double-action aluminium cable sheathing press was put into operation two years ago, since when important improvements have been incorporated. The complete operational sequence, from the charging of the billets into the induction furnaces to the delivery of the sheathed cable is now obtained fully automatically, in continuous cycles. Constant wall thickness of the sheath is ensured, even should extrusion have to be interrupted through unforeseen circumstances. Highly heat-sensitive cable cores can be sheathed in continuous duty, and though the pressure exerted is only 1,600 tons, outside diameters of sheath obtainable range from $^3/_{16}$ in. to 4 in., the minimum wall thickness being .008 in.

DOLLERY & PALMER LTD · 54, Victoria Street LONDON SW 1 · Lydgate Lane SHEFFIELD 10

METAL INDUSTRY

FOUNDED 1909

EDITOR: L. G. BERESFORD, B.Sc., F.I.M.

16 OCTOBER 1959 VOLUME 95 NUMBER 10

CONTENTS

PUBLISHED EVERY FRIDAY BY ILIFFE & SONS LIMITED

Editorial Offices: 9 Charlotte Street, Birmingham 3 . Telephone: Central 3206

Advertising and Publishing Offices: Dorset House, Stamford Street, London, S.E.1. Tel.: Waterloo 3333. 'Grams: "Metustry, Sedist, London"

Branch Offices: MANCHESTER: 260 DEANSGATE, 3; telephone, Blackfriars 4412 and Deansgate 3595 BIRMINGHAM: KING EDWARD HOUSE, NEW STREET, 2; telephone, Midland 7191. COVENTRY: 8-10 CORPORATION STREET; telephone, Coventry 25210. GLASGOW: 26a RENFIELD STREET, C.2; telephone, Central 1265

ANNUAL SUBSCRIPTION

HOME **£3 7s. 6d.** *OVERSEAS* **£3 12s. 0d.** *CANADA AND U.S.A.* **$10.00**

INCLUDING ONE COPY OF **METAL INDUSTRY HANDBOOK**, *PUBLISHED ANNUALLY*

METAL INDUSTRY

VOLUME 95 NUMBER 10 16 OCTOBER 1959

Scandinavia 1959

FOR two small nations, with populations of seven-and-a-half and four-and-a-half millions respectively, Sweden and Denmark offer a variety of non-ferrous metal enterprises which it would be difficult to surpass in many more-industrialized countries. Visitors to the many works which threw open their doors to members on the occasion of the Autumn Meeting of the Institute of Metals in Scandinavia could not but be impressed by the modern plant that was seen, and by the ideal working conditions that prevail. Full realization of the truth of this statement can only be obtained by a personal tour, but some impression can be gained from a study of the articles in this issue describing some of the works which were visited.

Thus, in Denmark, the visitors were not slow to appreciate the modern 2-high reversing mill, designed for both aluminium and copper, installed at the works of N.K.T. This, the fourteenth of its type to be installed, is equipped with A.C. motors running on the 10 kV grid and is completely automatized, the change-over from aluminium to light alloys taking only a few hours. In a private visit to a non-ferrous metals refinery in Copenhagen, we were impressed not only by the variety and magnitude of the processes carried out, but by the standard of housekeeping throughout the works—a standard which we have not seen approached in any other establishments of the kind we have visited.

In Sweden, apart from the excellent working conditions, it was particularly noticeable that a high degree of automation had been achieved in all the works visited. In one firm our attention was drawn to the number of items of plant—rolling mills and extrusion presses included—designed and installed by its own staff and also, we believe, manufactured by the firm itself. To some extent this was, of course, the result of war conditions, when Sweden was cut off from outside suppliers, but the practice is still being followed. Thus, a reheating furnace, of unique design, planned by the firm's engineers, is at present being installed for the reheating of continuously-cast aluminium slabs. This is a practice on which, naturally, there can be two distinct points of view, but we wonder how many British firms would entrust the design and erection of equipment of such magnitude and, incidentally, capital cost to their own engineering staff. Of interest, too, is the fact that it was obvious that the domestic market could not possibly absorb the tonnages of metal being produced, particularly of aluminium sheet. With labour costs claimed to be higher than in any other country in Western Europe, no doubt Swedish producers could give some pointers to their competitors in other countries on how to achieve satisfactory export figures. On a comparatively minor matter, the question of co-operation between producer and user, Sweden could also give some pointers to other countries. Evidence of this is afforded by a Paper, read at one of the Technical Sessions, on softness problems in the manufacture of fine copper wire for enamelling, in which the authors in their conclusion state that "co-operation between the different companies mentioned in this Paper has proved very fruitful and to the advantage of all parties concerned. It is, indeed, likely that co-operation of this nature constitutes the only rational means of reaching the bottom of, and solving, the problems that arise in the manufacture of a product of the nature discussed here".

Out of the MELTING POT

Observable

PRECIPITATION hardening copper-cobalt alloys have several features which enable a study to be made of the precipitated particles of cobalt responsible for the age hardening. The particles are of a "convenient" size and, being ferromagnetic, their size, number, etc., can be determined from magnetic measurements. In a research reported by J. D. Livingston, of the General Electric Research Laboratory, Schenectady, alloys containing 0·7, 1·3, 2·0 and 3·2 per cent by weight of cobalt were used. They were solution heat-treated for 30 min. at 1,000°C. and then quenched in iced brine. The quenched alloys were aged for various periods at temperatures between 550° and 700°C. In agreement with a previous investigation carried out on a single alloy composition, it was found from saturation magnetization measurements that in all cases substantially the whole volume of cobalt to be precipitated did, in fact, come out of solid solution in the first few minutes of ageing at 600°C. The subsequently observed changes in tensile yield stress were, therefore, due only to the coarsening of the particles constituting a nearly constant volume of already precipitated cobalt. The magnetic measurements served to determine the rate at which this coarsening took place, and to determine the particle size at which the maximum yield stress was reached. The optimum particle size from the point of view of the yield stress was found to have a radius of about 70Å, irrespective of the composition of the alloy and of the ageing temperature. The observations were interpreted in terms of internal stresses induced in the surrounding matrix by the coarsening of the particles of the precipitate, between which and the matrix there is complete coherence up to the critical optimum particle size, beyond which coherence begins to get lost, dislocations appearing at the particle/matrix interface. It is interesting to note that a theoretical consideration of the spacing of these dislocations gave a value of the diameter of the critical particle size of 160Å, which agrees very well with the experimentally determined figure of 140Å.

Neglected

WHETHER justified or not, there nevertheless exists an impression of a considerable difference in the approach to the two corner-stones (can you have two corner-stones?) of powder metallurgy: pressing and sintering. Take sintering first. With the exception of the relatively little used hot pressing, where problems of the tools and equipment loom large, sintering is what might be called a pure phenomenon: the compacted or even the loose powder is heated, and sintering occurs. Because of this, sintering is ideally suited to the fundamental empirical approach and to theoretical consideration. The results of this state of affairs are well known, so far as anything having the impressive bulk of these results can properly be described as really being well known. These results occupy many chapters, have filled many Papers, and have formed the subject of many a discussion, Symposium, colloquium, and the like. They range from the elementary one-variable-at-a-time, tensile-strength-increases-with-sintering-time kind, through the microscopic and sub-microscopic observations and theorizing on pore shapes and sizes, diffusion mechanisms, etc., to mathematical treatments of the phase equilibria and to near-philosophical speculations on the possibility or otherwise of reactions between solids. Compared with the lofty self-sufficiency of sintering, pressing is in the unfortunate position of requiring some sort of mechanical equipment, however simple, if it is to be brought about. Thus, to begin with, pressing, as it takes place within a die, is not even open to direct observation: has anybody ever tried using a glass die, or at least a die with one glass wall, through which the behaviour of the powder could be observed? Another unfortunate circumstance so far as pressing is concerned is that the mechanical equipment associated with it is able only too readily to tempt the mechanic and the inventor in every man to tinker, to improve and to design, and make something new. This leads to more and more complicated dies and presses, to attempts at isostatic pressing, the working of powder in sheaths, the rolling of metal powders, etc., and, as a consequence of this preoccupation with matters engineering, to a neglect of the powder and of what it does and what happens to it before, during and after pressing: elastic and plastic deformations and their after-effects, the behaviour of the air in the spaces between the particles (what has been happening to vacuum pressing?), the effects of lubricants, and the formation of the cold-welded bonds between the particles, to mention just a few subjects to be going on with.

Something To Learn

URANIUM is admittedly a somewhat unusual metal, and the number of people concerned with its fabrication is not very large. Nevertheless, developments in techniques of working the metal are worth watching, even if only with half an eye, either because of their intrinsic interest, or the possibility of adapting them or certain of their features to the working of less exotic metals, or even if only for the sake of the moral that can occasionally be drawn from them. A development which comes into the latter category is concerned with the rolling of uranium. Hitherto, the process has been complicated by the limited malleability of the metal at ordinary temperatures restricting reductions and necessitating frequent anneals, and by the reactivity of the metal at the hot rolling temperatures of from 400° to 1,050°C necessitating the use of a protective cladding of steel or other metal. A way out of these difficulties was provided by the discovery that the metal could be rolled with appreciable reductions at about 200°C., after preheating in an oil bath which leaves the metal with a thin protective coating of oil. Moral: instead of coping with the peculiarities of cold or hot working, spare some time to investigate the possible benefits of warm working. An example of a technique developed for uranium, but some features, at least, of which might be worth trying with other metals, is that of hot extruding uranium (powder) through a die made of dense graphite of high tensile strength, an extrusion pressure of up to 4,000 lb/in^2 being applied, the extrusion ratio being of the order of 1:4. The use of the graphite die is intended to avoid the alloying which is liable to occur between uranium and other metals at the extrusion die has an entry cone angle of 120° and a highly polished die has an entry cone angle of 120°C. and a highly polished bore. The extrusion container and the extrusion plunger are also made of graphite. Oxidation of the extruded metal and the graphite die is prevented by providing an inert atmosphere.

Skinner

S C A N D I N A V I A 1959

[Courtesy Swedish National Travel Association

The Stadhuset (Town Hall), one of the chief sights of modern Stockholm

INSTITUTE OF METALS FIFTY-FIRST AUTUMN MEETING

BY invitation of Bolidens Gruv AB, AB Svenska Metallverken, the Metallografiska Institutet and the Danish Society of Metals, the Fifty-First Annual Autumn Meeting of the Institute of Metals was held in Scandinavia from September 21-25. Opening at Stockholm, in the Kungl Tekniska Högskolan, the members, delegates and their ladies were cordially welcomed by **Mr. Carl A. Jacobsson** (managing director, AB Svenska Metallverken, Västerås). In reply, the President of the Institute, **Mr. G. L. Bailey,** expressed appreciation of the hospitality offered and thanks to the organizers of the meeting.

After a short adjournment, the President introduced **Prof. Erik Rudberg,** and asked him to deliver the 1959 Autumn Lecture on "Life With Metals—Now and Tomorrow". A vote of thanks to the lecturer, proposed by **Prof. H. Ford,** was carried with acclamation.

Technical Sessions

On the morning of Tuesday, September 22, two simultaneous discussions on "The Production of Fine Copper Wire for Enamelling" and "The Corrosion of Aluminium" (both reported in this issue), and a Paper on "Volume Increases in Fissile Materials on Neutron Irradiation and the Effects of Thermal Fluctuations", were held at the Terniska Högskolan. At the same venue, discussion of a Paper on "Extrusion as Compared with Other Methods for the Manufacture of Bar, Rod and Wire-Rod in Copper and Copper-Base Alloys" took place on the Thursday morning. Following this discussion, a formal vote of thanks to all those who had contributed to the success of the meeting, proposed by **Major C. J. P. Ball** and seconded by **Mr. D. C. P. Neave,** was carried unanimously.

In conjunction with a visit to AB Atomenergi, Studsvik, on September 24, the opportunity was taken of presenting and discussing two Papers relating to nuclear energy, namely "Swedish Research on Aluminium Reactor Technology", by **B. Forsén,** and "The Welding of Aluminium for Reactor Use," by **G. Norlander,** with **Dr. Roland Kiessling** acting as chairman.

Social Functions

Following usual practice, a number of interesting social functions were organized throughout the period of the meeting. While members attended the Autumn Lecture, their ladies were taken on a sightseeing tour of Stockholm, followed in the afternoon by a visit to the Northern Museum, where exhibits depict the life and work of the Swedish people throughout the ages. In the evening of the same day, delegates and their ladies were invited by the British Ambassador to a cocktail party at his residence. On Tuesday afternoon, ladies and members were able to visit the works of A.B. Gustavsbergs Fabriker, noted for its ceramic art ware. In the evening, a banquet and dance was held in the Golden Chamber of the Stadhuset, Stockholm, by invitation of Bolidens Gruv A.B., A.B. Svenska Metallverken and the Metallografiska Institutet.

An all-day tour to Uppsala took place on Wednesday, while on the following day there was a choice of visits to the Royal Palace and City Hall, Waldemarsudde, a former residence of the late Prince Eugen, housing one of the largest art collections in Sweden, and St. Erik's Brewery and Brewery Museum. The Council Dinner for the Institute's hosts was held in the evening. On Friday, ladies visited a glass works at Finspong, while members toured the works of A.B. Svenska Metallverken.

After these visits the conference moved to Copenhagen, where, on the afternoon of Saturday, a sightseeing tour of Copenhagen was followed by a reception at the Engineering Society Club by invitation of the Danish Society of Metals. On the Sunday, there was a choice between a visit to a modern pig farm at Astrup, by invitation of Mr. Svend-Bergsoe, and a coastal tour to Elsinore. The conference ended with a visit to the works of Georg Jensen (Silversmiths), the Royal Porcelain Factory and the Permanent Art Exhibition, all in Copenhagen.

Works Visits

Both in Sweden and in Denmark, a variety of works threw open their doors to delegates. Among those visited in Sweden were A.B. W. Dan Bergman (described in the later pages in this issue), A.B. Scania-Vabis, manufac-

turers of diesel vehicles and stationary engines, Telefonaktiebolaget, L. M. Ericsson (a description of which appears later in this issue), and A.B. Atomenergi, where research and development in atomic energy is carried out in collaboration with industry and many research laboratories.

Also visited were Liljeholmens Kabelfabrik, the laboratories of the Metallografiska Institutet and Kungl. Tekniska Högskolan (both described in this issue), Aga, specialists in radio-communication, lenses and prisms, and anaesthetic equipment, and A.B. Electrolux, manufacturers of vacuum cleaners, floor polishers and kitchen machines.

Members were also able to inspect the works of A.S.E.A., manufacturers of electrical equipment, and A.B. Svenska Metallverken, at Västerås, Väsby and Finspong, descriptions of which appear in this or later issues. Also described in this issue are the works of Bolidens Gruvaktiebolag at Boliden, Falun and Borlänge, which were visited by some of the members.

In Denmark, visits were made to the works of Andersen and Brunn's Fabriker A/S, A/S Nordiske Kabel- og Traadfabriker, the Welding Centre, and the Department of Metallurgy, Royal Technical University, Copenhagen, all of which are dealt with in later pages of this issue. A description of the works of Bürmeister and Wain's Maskin og Skibsbyggeri, which were also visited, will appear at a later date.

Personalities at the Banquet in the Stadhuset, Stockholm

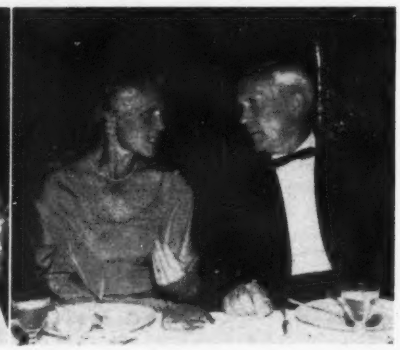
Mr. C. A. Jacobsson, Mr. G. L. Bailey

Mrs. Erik Rudberg, Dr. Maurice Cook

Mrs. G. Philipson, Prof. Hugh Ford

Mrs. G. Kihlstedt, Mr. E. H. Jones

Dr. Borge Lunn and Friend



Mrs. U. Notini, Prof. W. O. Köster

Some of the delegates and guests ascending the stairway to the banquet in the Golden Salon of the Stadhuset in Stockholm

Mr. and Mrs. P. G. Turner, Dr. and Mrs. W. O. Alexander, Dr. and Mrs. G. L. Miller

RESUMÉ OF PROCEEDINGS AT FIRST SESSION IN STOCKHOLM

Technical Sessions

TWO simultaneous discussions opened the scientific sessions of the Autumn Meeting of the Institute at the Kungl Tekniska Högskolan, Stockholm, on the morning of Tuesday, September 22. Session "A" was based on the theme "The Production of Fine Copper Wire for Enamelling," and Session "B" on "The Corrosion of Aluminium".

Three Papers formed the subject of discussion at Session "A", namely, "The Spring Elongation Test", by F. Schückher, Ph.D., and R. Nilsson (*J. Inst. Met.*, 1958-59, **87**), "Softness Problems in the Manufacture of Fine Copper Wire for Enamelling", by S. Carlén, R. Kihlberg and S. Lundquist (*J. Inst. Met.*, *ibid*), and "The Manufacture of Copper Wire for Enamelling", by R. D. Carter, Ph.D. (*J. Inst. Met.*, *ibid*).

The chair was taken by the President, **Mr. G. L. Bailey,** who, after a few brief words of welcome to the delegates, called upon Mr. A. B. Ashton to act as Rapporteur.

RAPPORTEUR'S REMARKS

A. B. Ashton (Frederick Smith and Co. Ltd.):

Present-day interest in the metallurgical aspects of enamelled wire production is reflected in the three Papers to be discussed. The subject as a whole divides itself naturally into three parts concerned respectively with the suitability of the copper as such which is of interest to copper producers; with wire fabrication procedures, which are of interest to wire makers, and with methods of testing, which are of interest to everyone.

Carter points out that enamelling demands a copper which must be low in annealing temperature, and must be consistent in this respect. He mentions that different brands of copper may vary by up to 60°C. in their annealing temperatures. He draws attention to the difficulties of correlating annealing behaviour with composition resulting from the very low impurity contents and consequent analytical difficulties.

Carlén and his co-workers have brought forward an extension of the well-known fact that impurities in solid solution raise the recrystallization temperature of copper. They postulate a reversible interaction between copper oxide and dissolved impurities, the equilibrium being temperature-dependent. A good deal of the Paper is concerned with experimental evidence proving that high-temperature treatments, and the use or omission of water quenching, have considerable effects on the springiness of the finished wire. All of this is consistent with the postulated reaction. They make a further reference to an additional effect of lead as one of the impurities by suggesting that it is present as lead oxide and has an effect on the equilibrium by moving the balance towards the metal oxide/copper side; in other words, that presence of lead favours a purer copper lattice and, by inference, is favourable towards a low recrystallization temperature.

Is there any other evidence available to support these two postulates? It will be noted that in Table I of the Paper (compositions of copper used) silver is omitted. Generally, silver content is regarded as significant.

Carter stresses the importance of smooth wire surface and, therefore, the importance of pinhole defect.

Hot rolling is stated to be the most potent source of surface imperfections. Quality requirements have started to sway design of hot mills, e.g. (1) Fault "overlap" prompting larger number of gentler passes. (2) Roll wear led to steel rolls instead of cast iron. (3) High pressure water jets lessened rolled-in scale. (4) Repeaters, guides, strippers, designed to prevent rod abrasion. He admits that shaving is necessary, while shaving is recorded in Carlén's Paper as a normal procedure. Assuming shaving to be necessary, what is the optimum depth of shaving cut?

The Paper by Carlén and his co-workers covers very comprehensively the influences of : hot rolling temperature; method of rod cooling (quench or slow); annealing the rolled rod (at 700°C.); intermediate annealing of wire; and reduction after intermediate annealing.

Index of effect is always the $\triangle L$ value measured in spiral elongation test at 0·5 mm. diam. after annealing for 1 hr. at 200°C. Results indicate that low hot rolling temperature, slow rod cooling, and annealing the rolled rod are all favourable. Intermediate annealing is favourable, but the temperature is critical for maximum improvement. Heavy reduction after intermediate annealing is unfavourable, but this effect is small so long as the reduction is below 95 per cent reduction of area.

Of these factors intermediate annealing is the most potent, but the temperature to achieve maximum effect is rather high, e.g. Fig. 2(d) shows increase from about 110 to about 410 in $\triangle L$, but the temperature to do this is 500°C. (This is high for annealing wire on reels). Carter also indicates the benefit of intermediate annealing. The Paper does not relate results to those obtained in annealing during enamelling, where heating is cyclic and short time.

Do these manufacturing variables show the same effects in enamelled wire as they do on the $\triangle L$ values given by the spiral elongation test?

Schückher's Paper is a comprehensive account of the spiral elongation test as it is used by A.B. Svenska Metallverken for assessment of wirebar quality. The test consists of converting the wirebar into a 5 mm. wire, annealing, forming into a spiral, extending the spiral by loading, and measuring the permanent extension. All physical variables and dimensions standardized and accurately controlled.

Conditions of test are chosen so that: (1) The deformation is almost pure torsion, (2) Sensitivity to annealing temperature of the copper is very high, (3) The parameter measured is such that large numerical values are measurable with good accuracy with little difficulty.

Mechanically, the test can be considered as a measurement of proof strain in torsion, using a test piece whose length is 2,000 times its diameter.

The Paper shows that spiral elongation values are proportional to the 0·1 per cent proof stress values of the material.

DISCUSSION

R. D. Burn (British Metal Corporation Ltd.):

There has developed a marked tendency, in view of the great and increasing importance of fine enamelled copper wire, to get out of true perspective its quantitative importance in copper wire production as a whole.

These three Papers have done much to rectify the general situation. Carlén, Kihlberg and Lundquist, for instance, begin both the introduction and discussion sections of their Paper by stressing "Since only a *small part* of wirebar production is intended for wire enamelling purposes . . . " etc.

The wirebar is still quantitatively the most important copper shape used—and while extruded base from billet comes into the picture for the larger sizes—fine wire production for enamelling must be less than half per cent of the total consumption.

The order of presentation of these three Papers seems a little illogical in that they are in inverse order.

The Paper by Carter is really the broad introduction to the theme as a whole, reviewing production, testing and enamelling.

Both Carter and Carlén and his colleagues refer to the difficulty of "stickiness", but Carter states that, other conditions being equal and perhaps critical, vacuum annealing can prevent "stickiness"—whereas Carlén says "it has, unfortunately, not been possible to verify this assertion".

The results of my personal enquiries to vacuum annealers support Carter. Yet is seems paradoxical, as one would expect that hot contact in a vacuum, with at least a certain degree of contact pressure, would favour diffusion and welding.

Does the effect of residual lubricant in, rather than on, the surface change the situation—and which is the correct answer?

In discussing enamelling defects from the rod mill, Carter refers to the interference by surface, and sub-surface oxide particles. Am I correct in inferring that the particles are cupric oxide from the rod mill and preheating furnace—and not the inherent cuprous oxide of the tough pitch copper, nor cuprous oxide formed from such cupric oxide which on occasions is reduced to the lower state by hot rolling into the copper? Does not the presence of cuprous oxide improve adhesion of the enamel whereas cupric oxide disrupts it?

None of these Papers seems to refer to the use of extruded rod for enamelling wire, and for the larger sizes is that not an important source?—especially in view of the high cost of shaving.

All three Papers presuppose that the rod from wirebar must be shaved as a precaution against possible residual rod mill defects. Mechanical tests referred to seem to be based on material 0·02 in. (0·5 mm.) or larger. Is that really *fine* wire?

Am I correct in understanding that a good deal of really fine wire (0·004-0·006 in.) is made for enamelling satisfactorily from a good standard wirebar and rod without shaving—if so, is *good* the operative word here?

In the development of vertically cast bars, even when scalped,

it has not been possible to prove for universal acceptance that they are better than ordinary regular bars for this type of fine wire (0·1 mm.). Is the rod mill quality the determining factor more so than the bar?

There is the further field of ultra-fine wire for enamelling—0·02 mm.—especially at £8,000 per ton. At about 0·00125 in. (0·03 mm.), material drawn *without* difficulty to *that* stage begins to give trouble due to breaks—are they due to the volume effect of the set oxide making its presence felt?

The importance of rod surface is stressed by all authors and Carlén refers to the Ox-off process versus shaving. The furnace treatment with hydrochloric acid gas in an oxidizing atmosphere, followed by quenching and pickling, must remove all surface oxide, except in very deep laps which must, however, then become visible—and also the copper dust which otherwise arises from the surface cuprous oxide with sulphuric pickle. Does the process give a surface as good as shaving, with less metal loss? The beneficial effect that can arise from the heat-treatment as such, seems fortunately fortuitous.

An interesting and important point about the Paper by Carlén is that it is the result of co-operation and close liaison between wirebar maker and user. The sort of co-operation which from time to time has always proved of mutual benefit, leading also to the benefit of later manufacturers and users of the product for all time.

Of particular value in the Swedish domestic set-up, the authors suggest, quite rightly, that for this particular problem they have developed and supplied a key to such co-operation being applied universally.

In a customs refinery, slight but definite variations, which can occur from charge to charge, are unavoidable But the major part of electrolytic copper supplied to the United Kingdom comes from four major refineries whose ore bodies and mining and recovery methods change not at all, or very slowly. Their products are easier to control and, in fact, variations other than sulphur and oxygen are almost undetectable over long periods of time.

For about 80 per cent of the wire produced from any good standard wirebar, these differences are not even noticed—hence, perhaps, the scepticism that used to persist that certain brands *are* particularly suitable for certain special jobs. These Papers highlight the fact that this can be true—and the difference due to the different rates of initial work hardening caused by impurities—or their variations—and maybe combination—can now be fairly readily expressed by a test which has a sensitivity beyond present methods of routine analysis or determinations of electrical conductivity.

It is interesting to hear from time to time the various opinions as to which are the key impurities responsible. Some say selenium, some iron, some antimony or arsenic, some silver, and so on, but very few consider sulphur or oxygen.

The analysis of the various coppers in relation to their behaviour given by the authors is a good picture, but they omit silver and selenium. These analyses also illustrate the author's own work on the use of lead to reduce the effect of sulphur.

The truth can well be that all the varying opinions are each true in its specific instance and the limitations of even modern methods of routine analysis begin to become apparent.

The coppers produced from oxidized ore bodies by electro-winning are the ones, other things being equal, which give the maximum $\triangle$L figures. Those are the coppers that are also the most suitable for the manufacture of copper-oxide rectifiers.

The coppers which give the best glass-to-copper seals, even if they cannot be used for that in practice, are tough pitch. They are also the coppers which give the most serious problem for scale removal, e.g. inside tubes if open fire annealed.

The spring elongation test is an ultra-sensitive test of purity, other things being equal. Is scale adhesion—which, unfortunately, cannot be determined or expressed in a neat number like $\triangle$L—also a key to impurity?

All these coppers are very low in silver. Smart and Smith show that silver alone at the low concentration of the average electro-copper, is an impurity with very low effect, although it is one which remains in solid solution without any reference to the oxygen balance or lead content.

There is no reason to suspect that they are at all wrong. So in certain cases, does silver act in conjunction with selenium and/or sulphur—in virtue of the presence of Ag_2Se or Ag_2S—two very stable compounds which can exist in solid solution, or even metastable solid solution, when the mechanical effect still applies.

Bear in mind how the authors have shown that stabilizing heat-treatment can reduce to some extent what would otherwise be the greater effect of impurities.

The third Paper, by Schücker and Nilsson is one of those singularly efficient Papers which leave little for discussion.

The interesting thing is that they show why a test based empirically on rule of thumb development along the practical lines in which the material is used is more sensitive than any other means at our disposal.

High conductivity copper is used for many things other than wire for enamelling, including a good deal of strip and sheet production where electrical conductivity does not matter and where it might be a bit better, in the finished form, if it were less pure than now.

If all high conductivity wirebars are to be suitable for enamelling wire, as has been hinted on occasions, such bars would be far from suitable for their present uses for many other semi-manufactures.

A standard specification test for $\triangle$L has a very definite place in the scheme of things—but that is in a *wire* specification and not in a *wirebar* specification.

Carlén and his co-authors give a very logical and practical set of instructions how to obtain the right copper for wire for enamelling, without imposing on other users any risk of getting copper which is less suitable than they get now.

R. D. Carter (British Insulated Callender's Cables Ltd.):

Deep shaving is necessary to the extent of 0·01 in. on untreated rod. The best method is to hone, when the defects come off as dust. "Stickiness" is generally reduced by vacuum annealing, the film of oxide inhibiting the welding process.

S. Lundquist (Bolidens Gruv AB):

The influence of silver in our copper is not marked, it being present only in the region of 5-10 gm/ton. No information is available concerning the effect of selenium, as we were not able to analyse for it.

R. Eborall (British Non-Ferrous Metals Research Association):

It is implicit that softness is desirable in the manufacture of copper wire, but not in all applications of the metal. According to Carlén, the proper solution is to disregard the composition of the wirebar and apply a suitable annealing treatment. Is this acceptable?

With regard to the spring elongation test, was the surface strain of 10 per cent chosen deliberately? An intermediate anneal at 700°C at the rod stage was standardized in the test. This seems fairly high and why, therefore, was it chosen?

R. Kihlberg (AB Svenska Metallverken):

The temperature of 700°C. was chosen in order to eliminate the influence of any variation in hot rolling temperature. We were attempting to simulate conditions in the hot rolled state.

C. Blazey (Metal Manufacturers Ltd., Australia):

There is a marked difference in any one rod. The softening rate of the front end is higher than that of the back end. The biggest variation in softening properties is always to be found in coppers of the highest purity, and these also show the greatest variation in annealing properties. High-purity coppers are also more sensitive to variations in hot working.

No mention is made in any of the Papers of cracks in wirebars. These are more common than is generally believed. What is the effect of cracks on surface quality, and what are the causes of cracks in wirebars?

SESSION "B"

WITH **Dr. Ivor Jenkins** in the chair, a discussion of "The Corrosion of Aluminium," arranged by the Nuclear Energy Committee, was held simultaneously with Session "A". Three Papers, presented by Prof. J. G. Ball as Rapporteur, formed the basis of discussion. They were "Some Properties of Oxide Films Formed During Aqueous Corrosion", by J. S. L. Leach, Ph.D. (*J. Inst. Met.*, 1958-59, **87**); "Aluminium Alloys for Water-Cooled Power Reactors", by E. C. W. Perryman (*J. Inst. Met., Ibid*); and "The Corrosion of Aluminium and its Alloys by High-Pressure Steam", by N. J. M. Wilkins and J. N. Wanklyn (*J. Inst. Met., ibid*).

RAPPORTEUR'S REMARKS

Prof. J. G. Ball (Royal School of Mines, London):

Dealing with different aspects of corrosion processes, the first Paper by Perryman discusses the corrosion of complex aluminium alloys in static and moving water at temperatures up to 300°C. The second, by Wilkins and Wanklyn, investigates the resistance of certain aluminium alloys to dry steam in the temperature range 270°-500°C. The third describes a method of measuring the physical properties of oxide films as they form during the corrosion process.

Although commercial purity aluminium can be used in water at a low temperature of about 100°C., it is subject to inter-granular corrosion at, say, 260°C.—a typical reactor temperature—blisters form below the metal surface, and give rise to rapid corrosion.

Additions of nickel and iron prevent blistering and inter-granular attack and give alloys which might compete with Zircaloy for reactor use.

Perryman's Paper is a careful and thorough investigation of the potentialities of such alloys for pressure water reactors. Two types of test were undertaken and significant differences in behaviour in these two types of test were noted: (1) static tests

in autoclaves; (2) dynamic tests in loops with a water velocity of 20 ft/sec. over the specimen surface (turbulent conditions).

Corrosion was assessed by weight gain in static tests, but by dimensional change in dynamic tests because of dissolution.

From an initial series of aluminium-nickel-copper and aluminium-iron-nickel-silicon alloys, two were chosen from static test results for further work: 0·5 per cent nickel-0·5 per cent iron-0·2 per cent silicon, and 2·0 per cent nickel-0·5 per cent iron-0·2 per cent silicon.

The first series showed that aluminium-nickel-iron alloys were superior to aluminium-nickel, and that for a given iron content there was an optimum silicon content.

Work on static tests on these alloys at 300°C. showed that the film formed consisted of two layers—an outer crystalline one and an inner one containing particles of the aluminium-nickel-iron phase. The attack was more uniform on the high nickel alloy and the rate of corrosion was lower.

Measurements of layer thicknesses in the film showed that the outer layer was of the same thickness for the two alloys, but the inner layer was thicker and the corrosion rate higher for the low nickel alloys. This suggests that the inner layer is the rate controlling part of the oxide film.

A third layer might exist, as at high temperatures (350°C.) a third layer is detected, and it is the only part of the film containing uncorroded particles of the compound.

Further small additions of titanium, beryllium and zirconium to the low nickel quaternary alloy aluminium-nickel-iron-silicon, showed that in static testing the rate of corrosion was decreased and was more uniform. Further tests showed that similar additions to the higher nickel content alloys gave further corrosion resistance again—indicating that the effects of nickel and the small quantities of titanium, beryllium and zirconium are additive.

In the dynamic tests in loops, a somewhat different picture emerges—earlier work in various laboratories had revealed inconsistencies in results obtained from dynamic tests, and it was supposed that the ratio of specimen area to volume of water in the loop was important as this would influence the rate of saturation of the loop water with corrosion product.

The effect of the surface area : volume ratio has been shown in this work to be important, especially in the range up to about 70-100 cm^2 specimen area to a litre of water in the loop.

Above the value of 170 cm^2/litre the ratio does not appear to be important.

With this variable removed (using 500 cm^2/litre), the investigation showed that alloy composition in the range from 0·5 to 2 per cent nickel, with or without trace additions (titanium, beryllium, zirconium) does not significantly influence corrosion rate. Further, it was noted that position in the loop is important—samples upstream corroded more rapidly than samples downstream. This indicates that the effect of the inhibitor is lost during a circuit of the loop.

Further, samples placed in the loop after a test has been proceeding for some time show an initially higher rate of corrosion than the original samples but, after a time, the rate settles down to that of the original samples.

An effective method of reducing the corrosion rate was found in the so-called "pre-filming", i.e. formation of a film in static water before placing the specimen in the loop. A factor of about 5 times reduction in rate was obtained by this method.

The effect of water composition was investigated, with particular reference to SiO_2 content in solution. Other investigators have shown that phosphoric acid is an effective inhibitor, but values of *p*H of about 4 must be maintained—such a low *p*H would be a limiting factor in circuits containing mild steel or stainless steel.

It was also known that SiO_2 was an effective inhibitor in static tests and might be capable of operating at a higher *p*H than phosphoric acid, i.e. about 7 or slightly less. Static tests demonstrated the effectiveness of SiO_2 as an inhibitor in neutral, or nearly neutral, solutions. The optimum content was in the range 300-1,000 p.p.m.

Dynamic tests confirmed this result, even though the tests were carried out at low surface area : volume ratios. However, although the general corrosion was low severe pitting was encountered. The effect of heat flux during reactor operation is suspected to cause enhanced corrosion, and the present investigation confirms this, although the results are rather incomplete.

Attempts were made to correlate corrosion behaviour with metallographic structure. The general nature of the corrosion results suggests that the ternary compound $FeNiAl_9$ is more effective than the binary $NiAl_3$.

One investigator supposes that this is due to the finer form of the particles of $FeNiAl_9$ than either $NiAl_3$ or $FeAl_3$, but the present investigators do not wholly agree with this.

The present observations indicate that the removal of fine particles from a structure of mixed particle sizes improves corrosion resistance, e.g. the addition of beryllium tends to reduce the number of fine particles and possibly to increase the number of large particles (beryllium improves corrosion resistance). It is even suggested that the less uniform attack in the low nickel beryllium-free alloy is due to the presence of mixed size particles, the rapid attack taking place in regions of fine particle size.

In the dynamic tests, these correlations cannot, of course, exist as there is little sensitivity to alloy composition.

The low mechanical properties of the alloy led to attempts to obtain additional strength by the addition of magnesium. However, such alloys were found to be very prone to intergranular corrosion and would not be satisfactory in the normal wrought condition.

However, the use of "atomized" alloys showed considerable promise—in this technique, the molten alloy is atomized in air or water and subsequently fabricated by powder techniques. The few tests reported indicate good corrosion resistance of such alloys, combined with good mechanical properties.

Fabrication appears to present no major difficulties, but the coarse structure associated with a fusion weld can lead to enhanced corrosion rates, and for this reason pressure welding is probably the necessary method of joining.

The Paper ends with an excursion into the "Alice in Wonderland" world of reactor economics and comes to the disappointing conclusion that the aluminium alloys cannot compete with zirconium—it is, of course, implicit that this conclusion applies to high-temperature applications and would not be valid for lower temperature. The permanence or transience of such a conclusion is probably a matter for debate.

In the second Paper, by Wilkins and Wanklyn, corrosion in static high pressure dry steam has been investigated between 270°C. and 500°C., using an aluminium-nickel-iron alloy with 2·5 per cent nickel and 0·5 per cent iron, and also some samples of S.A.P.

Control of pressure was difficult in the apparatus used and experiments were consequently made at constant time and variable pressure. Dry steam from start of test.

At 325°C. it was possible to conclude that the rate of corrosion (as determined by weight gain) is proportional to the fourth power of the steam pressure for a given time and, for given pressure, the rate is parabolic with time, and the corrosion proceeds by uniform film growth.

At lower temperatures, down to 270°C., it is inferred that, for a given pressure, there is an increase in corrosion rate, although the basis of this conclusion is somewhat uncertain because of the small number of results.

At the higher temperatures of 400°C. and 500°C. some specimens showed good resistance to corrosion, but in some cases (about 50 per cent) heavy penetrating attack developed. This local attack could develop rapidly over the whole specimen and result in the disintegration of the specimen to a powder consisting of about equal amounts of oxide and metal.

At 500°C. the rapid attack did not produce a powder but caused a general enlargement of the specimen, which retained its shape and even identification marks.

By contrast, similar experiments on S.A.P. showed that corrosion resistance was poor up to 325°C. and good at 500°C. At 270°C. a solid black product was formed as a result of corrosion and "growth" occurred in layers. At 325°C. the attack took place in two stages—first, an undermining effect of layers probably associated with the structure, and second, the eruption of blisters and formation of a voluminous product.

These results suggested the combination of the properties of S.A.P. conferred by the oxide with the properties of the nickel-containing alloy. Consequently, experiments were made on S.A.P. made from aluminium containing 1 per cent nickel, and the results indicate that good corrosion resistance is obtained over the range from 305°C. to 435°C.

In discussing their results on the aluminium-nickel-iron alloy, the authors conclude that the parabolic nature of the corrosion-time curve shows that control of the corrosion process is to be found within the film, and they proceed to examine the reasons for the extreme pressure sensitivity observed. They suggest that in low-pressure steam the film is Al_2O_3, and that increased pressure favours the inclusion of hydroxyl groups to form a less protective monohydrate.

The effect of the alloying elements might be to vary the proportion of hydroxyl group in the film and thereby to influence ionic mobility and, as a consequence, rate of corrosion.

The fact that a high proportion of metal is found in the powdered corrosion product of the aluminium-nickel-iron alloy (and not in pure aluminium) leads the authors to suggest that in the alloy there are chemically-favoured regions for attack which are not necessarily grain boundaries.

The retention of shape after complete attack at 500°C. is suggested by the authors to be possibly due to the sintering of oxide-covered particles which, at 400°C., are formed without subsequent sintering.

The penetrating attack at 400°-500°C. is in some way prevented by the oxide in S.A.P. and, although there are some suggested mechanisms, this behaviour still requires a convincing explanation.

The third and final Paper, by Leach, presents some results on oxide films which might find application in explanation of some of the phenomena presented in the other Papers, even though the data outlined were obtained mainly on uranium.

The essence of the Paper is in the application of a technique for determining the electrical properties of an oxide film during its formation and without its removal from the corrosion environment.

The test specimens consisted of α-uranium and uranium-12 per cent molybdenum alloy heat-treated to retain the γ phase. They were arranged in a test cell containing solutions giving, respectively, *p*H values of 1, 8·4, and 13. Arrangements were made to reduce the free oxygen content of the test solution to low level before introducing the test electrode and making the experiment.

Measurements of capacity and resistance could be made when the test electrode was free from loading or D.C. polarization, and results could be obtained in agreement with those obtained from a potentiostat, provided the period for the applied potential was short; at longer times the capacity increased with time and, presumably, with thickness. The capacity also increases as the potential becomes less negative and these results suggest that valency changes are taking place in the oxide. The conductivity under these conditions is almost zero—the conditions being a hydrogen-free specimen in the γ-phase.

Cathodic charging of the specimen gives a somewhat different picture. At potentials between $-0{\cdot}3$ and $-1{\cdot}0$ V, the conductivity of the film is greater than in the hydrogen-free condition by a factor of about 25, while beyond $-1{\cdot}0$ V there is a sudden increase in conductivity giving values up to 500 times that of the hydrogen-free state.

There is, however, no significant change in the capacity values from those of the hydrogen-free state, indicating that the thickness of the oxide film is substantially the same for the two conditions of the specimen.

With α-uranium, the capacity increase at more positive potentials is greater than with the γ-alloy. The conductivity shows high values at less negative potentials and lower values at more negative potentials without the increase noted with the γ-alloy.

Results on hydrogen-free α-uranium were very time-sensitive and are not reported, but the general effect was that the conductivity increased rapidly from low values to the values for hydrogen-containing samples. Changes in *p*H of the cell solution with γ-alloy specimens showed that the potentials at which conductivity increases occurred were varied, and it is suggested that this is associated with the differences in potential required, at the various *p*H values, to produce a given hydrogen ion concentration.

The significance of these results lies in the proposed correlation between enhanced corrosion rates in uranium, zirconium and aluminium, and the increased conductivity of the oxide film which is presumably associated with a high hydrogen content, the onset of enhanced corrosion being delayed in materials with a high solubility for hydrogen which will delay the build-up of a concentration sufficient to influence the film properties, noting, however, that film thickness is probably not an important variable as it appears to be constant for the conditions reported.

Possible mechanisms for the effect of hydrogen on the oxide properties are discussed, and it is concluded that the important influence is electrical rather than mechanical—i.e., causing a change in diffusion rates within the oxide rather than by directly causing mechanical failure by cracking. Cracking, however, might occur as a result of increased corrosion rates introducing internal stresses into the oxide.

It follows that studies of oxide films away from their corrosion environment are probably misleading because of the likely loss of hydrogen and its associated effects. It also follows from this suggested mechanism that measures which decrease the amount of hydrogen in the oxide film will decrease the rate of corrosion. Examples in support of this are:

(1) Addition of zirconium to uranium delays onset of breakaway corrosion,

(2) increasing solubility of hydrogen in uranium by stabilizing γ,

(3) decrease in rate of corrosion by making aluminium the anode in a corrosion cell,

(4) additions of iron and nickel to aluminium to provide points of low hydrogen overpotential and thus permit evolution of hydrogen as a gas,

(5) reduction by large factors of corrosion rate of titanium by making it an anode in a corrosion cell,

(6) corrosion rates of allotropes of manganese are lowest in the forms having greatest solubility for hydrogen.

[Courtesy National Travel Association of Denmark

Nyhavn and the canal in Copenhagen, with the naval memorial—an old anchor—in the foreground

Works Visit

AB Svenska Metallverken

By L. TILLBERG

FOR a long time copper and brass have played an important part in Sweden's economy. Copper ore has been mined since the thirteenth century, and products made of copper and its alloys have been manufactured on an industrial scale for several hundred years. In 1607, the Swedish Crown established at the village of Skultuna a brass factory which later became part of AB Svenska Metallverken. Thus, Metallverken, or "Svenska" as it is often called abroad, could celebrate its 350th anniversary in 1957, although the festivities were mainly characterized by the fact that it was 50 years since the company began operating under its present name. In 1907, AB Svenska Metallverken was formed through a merger of the three leading copper and brass works. The largest unit in this group was located at Västerås, which became the centre of the new company's activities.

A few years later, another metal-working company came into existence at Finspong, a small town in central Sweden with industrial traditions since the middle of the 16th century. The two companies at Västerås and Finspong developed at about the same pace and were making the same range of products. In 1942, Metallverken acquired a controlling interest in the Finspong Works. By this transaction, the prospects of rationalization and modernization of the Swedish production of non-ferrous semi-finished products were radically improved, and an organization was formed which could compete in size and efficiency with other European metal works. The manufacture of each range of products could now be concentrated at either of the plants, and, with a few exceptions, it was decided to locate the production of light alloy semi-manufactures at the Finspong plant whereas the Västerås and Granefors divisions took over conversion of copper and brass alloys. This concentration enabled the benefits of mass production to be realized.

To-day, the company's annual production of semi-manufactures totals well over 100,000 tons, roughly 25 per cent being light alloy goods. Except insulated cable, Metallverken makes a full range of semi-manufactures in copper- and aluminium-base alloys in the plants at Västerås, Finspong and Granefors. Two factories at Skultuna and Upplands Väsby make end products in various stages of finish, and a couple of smaller plants for special products complete the organization, which employs about 5,500 people. The head office and general sales office are located at Västerås.

The company has itself designed and built a substantial portion of its equipment, such as strip mills, wire rod mills, a tube-reducing machine, wire drawing and stranding equipment, and several other machines. A special department was set up, originally with a view to designing furnaces suitable for the company's own needs, but a growing demand in other branches of industry for this department's products soon made it desirable to give the organization the status of a limited company, which was called Ugnsbolaget. This wholly-owned subsidiary now sells the main part of its production to customers outside the Metallverken group.

Västerås Works

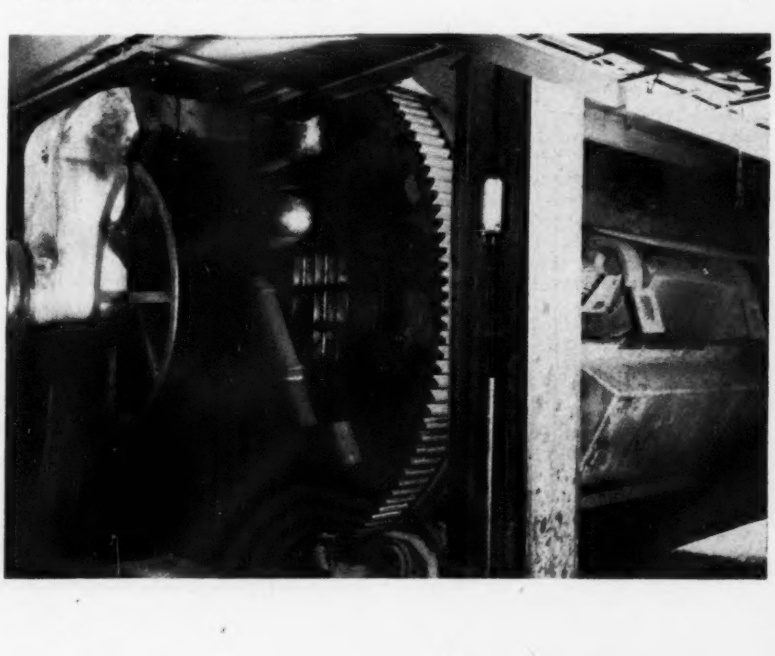
The plant at Västerås is responsible for supplying most of the semi-fabricated copper and brass which the domestic market can absorb. Production includes sheet, strip, rod, bars, sections, wire and cable in all the customary copper-base alloys, as well as steel-aluminium conductors. Small arms ammunition is also made at Västerås, and there is a manufacturing department which turns out powder metal products, etc. In 1958, about 75,000 tons of "semis" were produced. All in all, 1,800 people are employed at the Västerås Works.

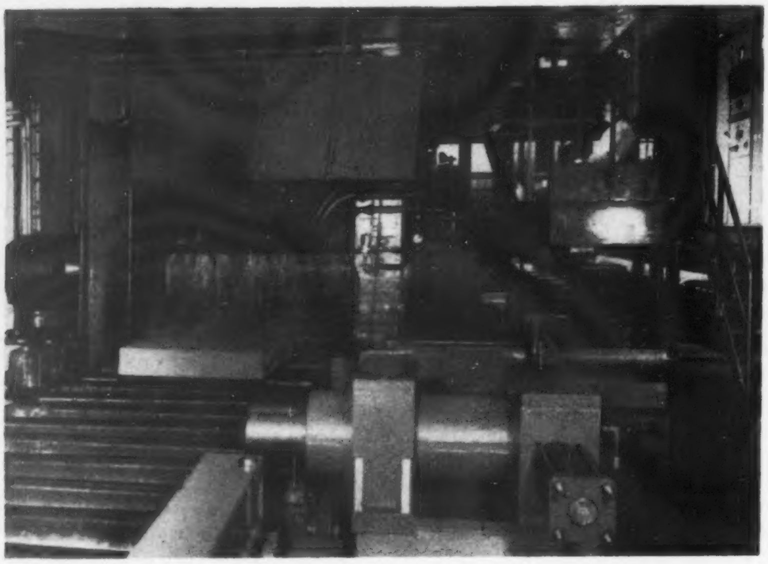
The melting shop is equipped with low-frequency induction furnaces of the channel type, having detachable inductor units. The two largest, which were built by the company, are rated at 1,000 kW, each being capable of melting 9,000 lb. of metal per hour. Three 250 kW Ajax-type double channel furnaces are used for swarf smelting at the rate of 2,000 lb/hr., and six smaller units each have a capacity of about 1,100 lb/hr. Bulk production brass ingots of standard composition are cast in a semi-continuous machine designed and built at the plant. Non-oscillating moulds with untapered chromium-plated walls are used. The holding furnace takes a maximum charge of 10,000 lb. and is fed via ladles from the 1,000 kW furnaces. The largest ingots which can be cast on this machine are 24 in. × 8 in. or 12 in. dia. and maximum length, except for the largest types of slab, is about 15 ft. Most of the conventional casting is done in solid copper moulds with drilled cooling channels. The remaining moulds of older types are gradually being substituted, as the solid copper type has proved very economical in spite of a high initial cost.

The annual capacity of the melting shop amounts to some 60,000 tons of ingots. 140 different alloys are on the programme, but the four most common account for about 85 per cent of the output.

The copper and brass extrusion department has an annual capacity of 18,000 tons of rod, bars and sections

1,000 kW low-frequency induction furnace





2-high reversing hot mill

distributed between some 12,000 different orders. A modern self-contained oil-hydraulic Loewy press with an extrusion force of 2,500 tons is used for bulk production of round and hexagon rod, mostly in leaded brass, and rectangular copper extrusions for strip and bus-bars. The press is extensively mechanized and is served by a crew of six, including a furnace operator and two transport workers. Rod as large as 2 in. dia. is extruded into electro-hydraulically driven coilers from which the coils are transferred to an automatic air-cooling and water-quenching line. By-passing the coilers, heavier rod and bars can also be produced, but these are normally extruded in an older 1,250-ton press. The furnaces are equipped for firing with oil or gas or a mixture of both. Sections are made in a special department using an old press with a nominal capacity of 1,500 tons. The processing equipment further includes five drawing machines (Schumag and Lomatic), drawbenches, sizing mills, straighteners, pickling plants, annealing furnaces, etc. The department has a tool room, the activities of which are mainly concentrated on storing and maintenance, but new tools are also made to some extent. The tool room, which besides conventional tool machines also has a spark erosion machine, employs about 20 workers.

Adjacent to the extrusion shop there is a highly-mechanized department for storing and despatching rod and bars.

About 20,000 tons of copper alloy sheet, strip and circles are produced annually at the Västerås Works. The production is subdivided into three categories: heavy plate, which is being rolled in widths up to about 10 ft. in very old two-high mills; strip in widths up to 14 in. and gauges between 0·004 in. and 0·1 in., and strip in gauges from 0·004 in. to 0·060 in. in widths up to 40 in. The two mills are placed in bays on each side of a central hall containing machine rooms and heating furnaces. The furnaces and the drive machinery are common to both mills, which are run alternately. The narrow strip hot rolling mill is a two-high reversing universal mill with roll dia. 29 in. and 29 in. roll face.

The other hot mill is a Morgårdshammar two-high reversing mill with 29 in. roll dia. and 65 in. roll face. The mill is equipped with programmed screw-down control receiving impulses from a punched card. The card containing the rolling programme can be changed in 15 sec. An edge trimming machine is used for trimming when rolling leaded brasses after the strip has been cooled in water spray.

After hot-rolling, oxides and surface defects are removed in Torrington machines. After one side has been milled the strip is fed out upon a special roller table which forms a loop over the machine so that the strip is turned over as well as returned to the entry side.

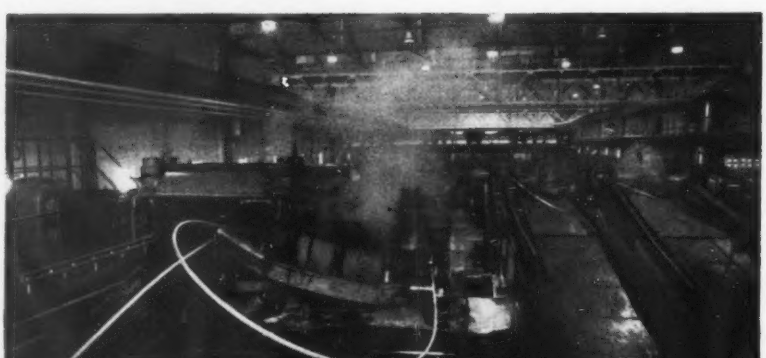
A four-high Schloemann cold rolling mill is used for breaking down heavy gauge strip starting at 0·3 in., for finishing medium gauge strip down to 0·008 in. and for temper rolling with reduction between 5 and 15 per cent. The auxiliary equipment includes a machine for breaking up coils, feeder rolls and an up-coiling machine. Work roll dia. is about 16 in., back-up rolls 40 in. and roll face 50 in. Maximum rolling speed is 600 ft/min. and main motor power 1,200 h.p.

Strip over 0·06 in. thick is coiled and then annealed in a pusher type furnace, and smaller gauge strip is fed through a continuous annealing and pickling plant. Because of frequent changes between copper and brass, no attempt has been made at controlling the furnace atmosphere.

Finished strip is edge trimmed, straightened and cut to lengths in an Ungerer plant with a maximum speed of 200 ft/min. A coiler can be inserted between the straightener and the flying shears when coiled strip is specified.

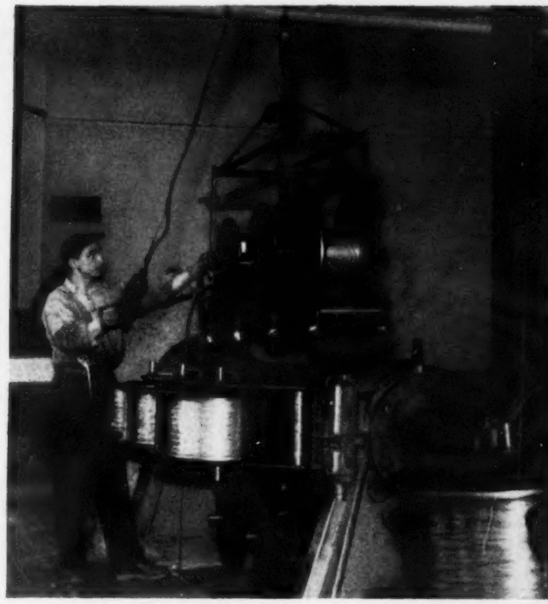
Aluminium cable for overhead conductors is produced with equipment most of which has been designed and built by the company. A fully-automatic wire rod mill rolls 250 lb. aluminium wire-bars down to $\frac{7}{16}$ in. in 16 passes with a crew of five, including the furnace operator and one hand to transport coils from the mill. The 6 in. × 6 in. wire-bars are heated to 450°C. in an oil-fired pusher type furnace and are automatically conveyed to the roughing mill. This consists of a three-high stand for the first eight passes and a tandem-mounted two-high stand for the ninth pass. In the first stand the bar is handled by pneumatically-operated manipulators, and a repeater leads it into the second stand.

Automatic aluminium wire rod rolling mill



The intermediate looping mill has two separately-driven trains in line having two and three stands respectively. Repeaters are used on both the square and the oval sides of the trains. The rod is finished in two continuous stands in which the drive motor, reduction gear and pinion drive have been combined in one unit. Finally, there are two coilers working alternately, the motors of which are synchronized with that of the final stand of the rolling mill. Finishing speed is about 2,000 ft/min. The mill, which is very compact, processes one wire-bar a minute, amounting to an average production of about 6 ton/hr. of wire rod. The quality of the rod is automatically controlled with electronic equipment.

Wire is drawn down to a minimum gauge of 0·07 in. in equipment consisting of five company-designed 13-draw slip-machines and one Morgårdshammar Bee-line nonslip machine. The wire rod coils are butt welded before drawing, and a special device stops the drawing machines when a pre-determined length of wire has been spooled on the reels.



Charging 24-spool stranding machine

The stranding equipment forms a system based on the reels being carried three by three in detachable box-like frames. Stranders and all auxiliary equipment such as spooling machines and transport devices have been designed to fit in with these frames. The strander body has a square section and four of the frames can be attached to each body, accounting for a maximum of 12 reels/strander. For production of multi-layer cable, two such machines are arranged in tandem. Each reel carries up to 160 lb. of wire and the machines run at 200 r.p.m. Single layer cable is produced in two Neuhaus tubular stranders. The stranding equipment is capable of producing about 15,000 tons of cable per year.

The copper wire rod mill is basically of the same design as the aluminium mill, except for the addition of a continuous finishing train. Standard 4 in. × 4 in. wire-bars are rolled down to gauges between ¾ in. and ¼ in. To roll ¼ in. rod, 18 passes are required of which the first seven are rolled in a roughing train consisting of a three-high and a two-high mill. Four intermediate passes are made in a looping mill and the remaining seven in a continuous train with four horizontal and three vertical mills with electronic speed control. The mill produces about 25,000 tons of copper rod per year, of which somewhat less than half is processed to round or flattened wire at the works, the rest being delivered in rod form. Copper alloys such as cadmium-tin-copper and 76/24 alloy are also rolled in this mill.

The wire drawing department has a number of slip and nonslip drawing machines, stranding equipment, single blocks, rod shaving units and wire flattening mills. The annealing equipment includes vacuum- and inert-gas batch-type bright annealing furnaces for coils and fine wire spools and a continuous furnace for annealing flattened wire on heavy size spools.

The department also has its own section for die maintenance and extensive equipment for quality control of manufactured products.

There is no central laboratory in the company's organization, and the individual works have been free to adapt the laboratories to suit their particular needs. At Västerås there are different departments for routine control, development and research.

Activities in the routine control department include carrying out investigations, advising production on control of materials and the statistical evaluation of test results and issuing certificates of analyses. This department has a section for chemical and spectrographical analyses of which about 65,000 and 200,000 respectively are carried out per year, and a section for testing mechanical properties.

The development department is concerned with production problems, spotting causes of trouble in the production departments and following up new production methods. To this end, the department operates a pilot plant which is equipped with a rolling mill, a drawbench and other machinery.

In the research department three sections are studying the physical properties of metals, metallography and corrosion.

Upplands-Väsby Works

With 650 employees, this division produces yearly about 800 tons of hot-forged parts in copper, brass and aluminium alloys, and pressure die-castings of which some 800 tons are made of aluminium alloys, 100 tons in magnesium alloys and about 400 tons in zinc alloy. In addition, 2,500 tons of plastics goods are turned out in the finished and semi-finished stage.

Hot forgings are produced in 90-300 ton friction screw presses as well as in crank presses from 75-300 tons. Of the latter, one is capable of producing cored forgings with cores from four edges. Electric furnaces are used for light alloys and for copper and brass when close temperature control is required, otherwise heating is done in oil-fired furnaces.

Zinc die-castings are produced in hot-chamber machines with die-locking pressures of up to 250 tons with pneumatically or hydraulically actuated plungers. For aluminium alloys, modern fully hydraulic cold-chamber machines of European and American manufacture are used, the largest of which have a die-locking pressure of 800 tons. The melting and holding furnaces used for these metals are of the low-frequency induction type. Magnesium, on the other hand, is melted in gas-fired furnaces and cast in hot-chamber machines with direct-air injection, of the company's own manufacture. Surface treatment of the castings includes polishing, anodizing, nickel-chromium plating, etc.

The bulk production in the plastics department consists of "semis" in the form of polyethylene tubing and film, and sheets of polystyrene and polyethylene. The extruders, which are designed and built by the company, produce tubes up to 16 in. outside diameter, and blown film having a flat width of up to 20 ft. Screw sizes are 2½ in. to 6 in.

Injection mouldings of polyethylene, polystyrene and nylon are also made. Parts weighing between 4 and 48 oz. are produced in semi- and fully automatic machines of European and American origin.

A description of the Finspong works of the company will be published next week, together with brief details of the Granefors and Skultuna works.

Part of the underground workings at the Laisvall mine

Works Visit

Boliden Mining Company

By M. BLOMKVIST

IN 1924, an important find of gold-bearing ore was made at Boliden, in Västerbotten, a province in the north of Sweden. The work of uncovering the ore body was, however, expensive and time-consuming, and it was not until 1926, when production began at the Boliden Mine, that economic returns were made.

At first the ore from the Boliden Mine was exported in its raw state. After extensive experiments and research work, a smelting works was erected during the years 1928-30 at Rönnskär, near Skellefteå. Prospecting was not discontinued, however, and since the discovery of the Boliden deposits the company has found several other ore bodies which are now being worked. At present the Boliden company has seven mines in production in Norrland, and five in the Bergslagen district of central Sweden. At the beginning of 1960 a new mine will be in operation in the latter district. In addition, the company is working the State mines in the Adak field in Norrland.

There are two main types of ore: complex sulphide ores and lead ores. The complex sulphide ores sometimes contain lead and precious metals, in addition to sulphur, zinc and copper. On account of the increase of the ore reserves, the Rönnskär Works has been extended considerably, and now comprises a copper works, lead works, and several by-product plants. Not only copper and lead, but gold, silver, selenium, arsenic, arsenic salts, lead oxides and sulphuric acid are produced. At the ore-dressing plants, pyrites and zinc concentrates are also produced.

Underground Mining

Practically all the mining of ore takes place underground. In principle the method is as follows. A shaft is sunk at the side of the field and a system of horizontal drifts and cross-cuts is driven at different levels into the ore body. After blasting, the ore is scraped down into chutes, loaded into trucks drawn by electric locomotives, and taken to a crushing mill. After being crushed, the ore is loaded, usually automatically, into skips which take it to the surface. All underground

Flotation of ore at the central ore-dressing plant at Boliden

drilling is done by means of compressed air machines and hard metal drills. Electric scraper hoists or compressed air-operated loaders are used.

An example of advanced mechanization is the Renström Mine. There, the tapping of the ore from the chutes, its transport to the underground crushing mill, crushing and winding the ore to the surface, are performed in an unbroken sequence in which the human element has been reduced to one man per shift. Special conditions prevail at the great Laisvall Lead Mine, situated in the largest lead deposits in Europe, on the borders of the mountain ranges, 50 km. from Arjeplog and 300 km. from the smelting works. There, the almost horizontal ore body, its thickness, and the strength of the rock, allow plenty of space for underground work. When the ore has been blown off the face it can be loaded with the help of electric excavators and conveyed by diesel-powered trucks or standard-gauge railway to underground crushing mills.

The metal contents of the ores are generally low. In addition, the finds are scattered over wide areas, and the transport distances to the smelting works are consequently great. The relatively high content of barren rock in the ore, together with the long transport distances, make necessary a reduction of the volume of the ores by concentration. A new problem emerges in connection with concentration. Several of the ores are so poor that they cannot support the costs of individual ore-dressing plants. Central ore-dressing plants, to which the mines in the neighbourhood send their ores, have, therefore, been constructed. They are large works, usually with a capacity of between 500,000 and 700,000 tons/year of ore. Thanks to these central plants, the company has been enabled to exploit low grade ores that would otherwise have remained untouched.

Above—Anode furnace in the copper smelting plant

Left—One of the bedding bins at the copper works at Rönnskär

Concentration is carried out exclusively by the selective flotation method. After the ore has been crushed in jaw and cone crushers to a size of about 4 cm., it is wet ground in mills with steel balls, steel rods or screened ore as a grinding agent. Practically all the different minerals are liberated in the resulting slime. The minerals are isolated in flotation cells with the help of frothing agents and small amounts of surface active chemicals, such as xanthates, lime, copper sulphate and sulphuric acid. Each individual mineral is extracted as a concentrated scum by varying the admixtures in separate groups of apparatus. The scum is transferred to filtering drums, where the water is drained off, after which the concentrate is dried, usually in oil-fired kilns. A considerable concentration of metal is obtained by this method. Concentrates from the ore from the Laisvall Mine, for example, have a lead content of 80 per cent, as compared with about 4 per cent in the original ore. The great amount of rock removed accompanies the waste water and is collected in special dams or, in certain cases, pumped back into the mine as filling material. Copper, lead, zinc, pyrites and arsenic concentrates are produced. When gold and silver occur in the ores they are found in the copper, lead and arsenic concentrates.

Anode casting in the Rönnskär copper smelting plant

A feature of the concentration processes is their high degree of automatization. Each plant is constructed specially for the ores in the mines it is to serve. At the central ore-dressing plant at Boliden, however, it is possible to treat all the types of ores the company extracts at present. The Boliden Works consists of two sections, one of which can treat ores containing up to four minerals, while the other can treat ores with up to three minerals.

The Boliden plant also includes the company's experimental station, comprising a full-scale pilot plant and concentration laboratories. There, research and testing are carried out with a view to improving methods of concentration and finding the best ways of concentrating new ores that are discovered by prospecting. The apparatus allows for the breaking down of an ore into five concentrates and waste matter. The results obtained are of great economic importance in the treatment of ores.

Rönnskär Works

The greater part of the concentrates are transported to the Rönnskär Works, mainly by rail, but also by road. Aerial ropeway transport is also used; from the ore-dressing plant at Kristineberg there is a ropeway 96 kilometres long to Boliden, where the concentrates are transferred to the railway.

Pyrites and zinc concentrates are exported from the harbour belonging to the Rönnskär Works. Copper, arsenic and lead concentrates are treated at the Rönnskär Works. The basic material also consists, however, of considerable quantities of material from other parts of Sweden, and even from abroad. This is true chiefly of the copper production, for which about two-thirds of the material used is drawn from practically all over the world.

Naturally, the competition for foreign materials, combined with long transport distances, contributes towards making extremely rational production methods essential at the Rönnskär Works.

Copper Works

The original copper works at Rönnskär, which began production in 1930, was adapted wholly to the type and quantities of ore extracted from the Boliden Mine. At that time there was no concentration method that could be applied to the Boliden ores, which are relatively poor in copper, but rich in gold and arsenic. When the works began operation the plant was very modest. It consisted of four small roasting furnaces, one silica-lined reverberatory furnace with internal dimensions of 5×24 m., and two small converters, $2 \times 2{\cdot}2$ m. in area.

The smelting capacity was increased rapidly, however. New departments were established, including electrolysis and cathode smelters. A metal works for gold and silver was erected in 1932-3, an arsenic works in 1934-5, and a selenium works in 1935-6.

As the reverberatory furnace was dependent on imported coal, the introduction of electric smelting was discussed as long ago as the last years of the 1930s, but, as a consequence of war-time conditions, it was not until 1946 that a decision was arrived at. By that time a comprehensive programme for the modernization and extension of the whole of the Rönnskär Works had been drawn up. This rebuilding went on until the end of 1958, when the final item of the rationalization programme, a new copper electrolysis works, was completed.

This modernization and enlargement of the copper works was carried out according to four main principles:

(1) The greatest attention was paid to such problems of hygiene that might arise on account of the occurrence of sulphur dioxide and arsenic trioxide in the various processes.

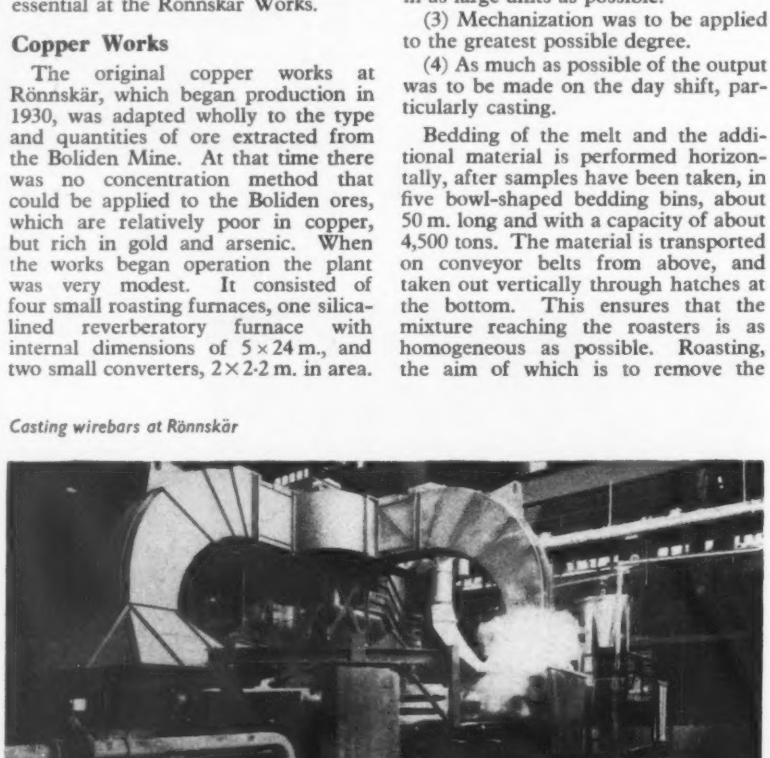
(2) Processes were to be carried out in as large units as possible.

(3) Mechanization was to be applied to the greatest possible degree.

(4) As much as possible of the output was to be made on the day shift, particularly casting.

Bedding of the melt and the additional material is performed horizontally, after samples have been taken, in five bowl-shaped bedding bins, about 50 m. long and with a capacity of about 4,500 tons. The material is transported on conveyor belts from above, and taken out vertically through hatches at the bottom. This ensures that the mixture reaching the roasters is as homogeneous as possible. Roasting, the aim of which is to remove the

Casting wirebars at Rönnskär



arsenic and part of the sulphur from the charge, is performed in multiple-hearth furnaces. The flue gases, containing arsenic trioxide and sulphur dioxide, are cooled in a cooling system to a temperature below 170°C., usually 130°C., whereby the arsenic is condensed and precipitated to the bottom of the cooling system. The gases then pass through an electric purification system, in which practically all the arsenic is extracted, and through a washing tower prior to going on to the sulphuric acid plant. One of the problems of roasting is to remove the arsenic and at the same time ensure that the gases contain as high a percentage of sulphur dioxide as possible. The raw arsenic, precipitated in the cooling and gas purifying plants, is transported through a tunnel to a raw arsenic storehouse, from whence it is taken direct to an arsenic refining works. The material that leaves the roaster contains about 15 per cent sulphur and less than 1 per cent arsenic. Further, it contains on an average about 16 per cent copper, 19 per cent silicic acid, and 27 per cent iron.

The electric smelter is equipped with six continuous Söderberg electrodes, with a diameter of 1,200 mm. The inner dimensions of the furnace are 6×24 metres, and it is probably one of the largest electric copper smelting furnaces in the world as regards smelting area. The slag from the furnace is granulated in a jet of water and, together with the water, it is pumped to a special area that is being filled up. Since the copper works began operation, the area of the site has been more than doubled by filling the shallow water with slag. A problem of smelting is to keep the copper content of the slag at a minimum. By means of continuous and careful sampling, and other measures, good results have been achieved.

The converter equipment consists of two horizontal converters, 4×9 m. in area and holding about 80 tons each. The converters are used alternately, so that one is always in reserve. A travelling crane, which lifts a load of 50 tons, transports the matte from the smelting furnace to the converter in ladles with a volume of six cubic metres, and the blister copper from the converter to the anode furnace. There are two cranes, also employed alternately. The anodes are cast in an automatic moulding machine. The anode weight is 285 kg. and the daily consumption of anodes in the electrolysis smelting works is between 500 and 600.

The capacity of the electrolysis works is about 45,000 tons of copper per annum. There are 336 electrolysis cells of about six cubic metres each. These are assembled in twelve groups with twenty-eight cells in each. The cells, or tanks, are made of concrete, painted with acid-resisting paint and lined with lead. The total electrode weight per cell is 10-12 tons. To convert the A.C. into D.C. for electrolysis there is a contact rectifier for 16,000 amps at a maximum tension of 140 V. An important part of the work of the electrolysis plant is to take charge of the anode slime, which contains the metals gold, silver and selenium, besides others. The slime is washed through valves in the bottom of the tanks into conduits leading into a tank in the cellar. From there, the slime is pumped into a sedimentation tank, where it is washed before being pumped to the precious metals plant. The pumping system for the cellar is automatic and the cellar is constructed as a closed unit, making it possible to collect all the solution and slime. The cathodes are melted in a 4,500 kW electric arc furnace. Melting is continuous and a stream of molten copper leaves the furnace at the rate of about 15 tons/hr. by way of a tilting low-frequency furnace which serves as a fore hearth to the moulding machines. The castings comprise wirebars, billets and cakes.

Interior of the new electrolytic plant at Rönnskär

Lead Works

The first lead works was built in 1941 and production was begun in 1943. Here, too, enlargements and modernization have taken place successively. Among other things, a lead sintering plant was constructed in 1955. The basic materials consist of lead concentrates from the company's own Norrland and central Swedish mines.

A survey of all the known methods of producing lead showed that not one of them was suitable for the fine-grained, 80 per cent concentrate from the refining works at the Laisvall Mine. As was the case with copper, a practically new process had to be developed. As Sweden was then, during the war, largely isolated from the rest of the world, and lead was urgently needed, the work had to be done quickly. When later it was desired to produce crude lead with a low sulphur content straight from the furnace by sintering the lead concentrates before charging, it was again found that none of the existing sintering methods was suitable. Again laborious research work had to be performed, before success was achieved.

In the lead producing process, the concentrates, which come by rail to Rönnskär, are stored in bunkers holding 12,000 tons. The first phase of the process, pelleting, is performed in pelleting discs and drums. The pellets consist of an outer shell of lead concentrate on a core which, from the inside, consists of return sinter, return dust and limestone powder. Lead accounts for about half the weight of the pellets. Sintering takes place on a sintering machine consisting of an endless grate under which a fan creates a considerable negative pressure so that air is drawn through the grate from above. The charge is lighted by means of an oil-fired ignition device. During sintering, about half the sulphur content of the charge is extracted, and the gas formed during sintering is drawn away into cyclones and filters. When completed, the sinter is crushed and screened; part is removed as return sinter, and the rest goes to the smelting furnace. The whole sintering process, from the moment the concentrate enters the sintering plant to the time the finished sinter is removed, can

be watched from a control room. Smelting is performed in an 8,000 kW electric furnace. During subsequent converting, the remainder of the sulphur in the raw lead is removed. Decoppering and de-silvering are carried out in refining vessels, and the moulding of lead ingots in a straight casting machine. Lead is produced in a standard quality for the manufacture of cables, and in extra pure qualities for lead oxides to be used in batteries and for other purposes. In addition, lead alloys are made in special plants.

By-Products

At the precious metals works, which was extended and modernized in 1953-5, the basic materials consist mainly of the sludge produced during the electrolysis treatment of anode copper, and of silver alloy which occurs during the refinement of lead. The gold produced here is 999·8 fine and the silver 999·6 fine. Apart from gold and silver, small amounts of platinum metals are produced.

At the arsenic works, where production was begun in 1935, the raw material consists, as already mentioned, of raw arsenic from copper processing, which is drawn partly from the great stocks that have been laid down during the course of years. Raw arsenic is refined by a wet process. Most of the arsenic trioxide obtained is exported, but a small part is used by the company for the manufacture of metallic arsenic and arsenic salts for wood preservatives, insecticides, weed killers and many other purposes.

The selenium works dates from 1936, but has later been enlarged. The raw materials used are partly a by-product from the precious metals works and partly waste matter from the refining of arsenic. The greater part of the selenium production is of special selenium with less than 0·005 per cent impurities.

The sulphuric acid factory started operation in 1953 in order to make use of the sulphur dioxide content of the flue gases from the roasters, smelters and converters in the copper works. These gases are further purified in washing towers and electro-filters, and then dried. The sulphur dioxide content of the purified gases is then converted into sulphur trioxide by the contact process, and the sulphur trioxide obtained is absorbed in concentrated sulphuric acid with the simultaneous addition of water. Manufacture includes both 96 per cent and 75 per cent sulphuric acid.

Among the other products of the by-products works are lead-bismuth alloy, which is made from dust containing bismuth obtained in the gas purifying apparatus of the copper converters, refined nickel sulphate, which is extracted from the nickel content of the copper smelting material and lead oxides such as pigment and glass, red lead, and battery oxides.

Intensive Research

Great attention has been devoted to research work. The company has laboratories and experimental plants for research in the spheres of prospecting and refining, and at the Rönnskär Works, there is a central research laboratory, where the main objectives are to discover better methods of extracting metals and chemicals from the raw materials, and evolving more effective methods of control. The laboratory includes departments for sampling, analysis, and physical, chemical and metallurgical research. It is extremely well equipped, and an extensive industrial library is at the disposal of the staff.

The company has also made great efforts to keep up a high standard of industrial hygiene and safety. The technical and administrative measures to reduce the risks to the workers are many and varied, and both the mines administration and the Rönnskär Works have permanently-employed physicians at their disposal, and special medical laboratories have been established as a step in the prophylactic health service.

In the large mining communities, run in conjunction with the company and the local authorities, are workshop schools to provide young people with a good technical training. The Rönnskär Works has a special industrial school for young people. For the training of foremen the company has its own courses, besides which outside educational bodies are employed.

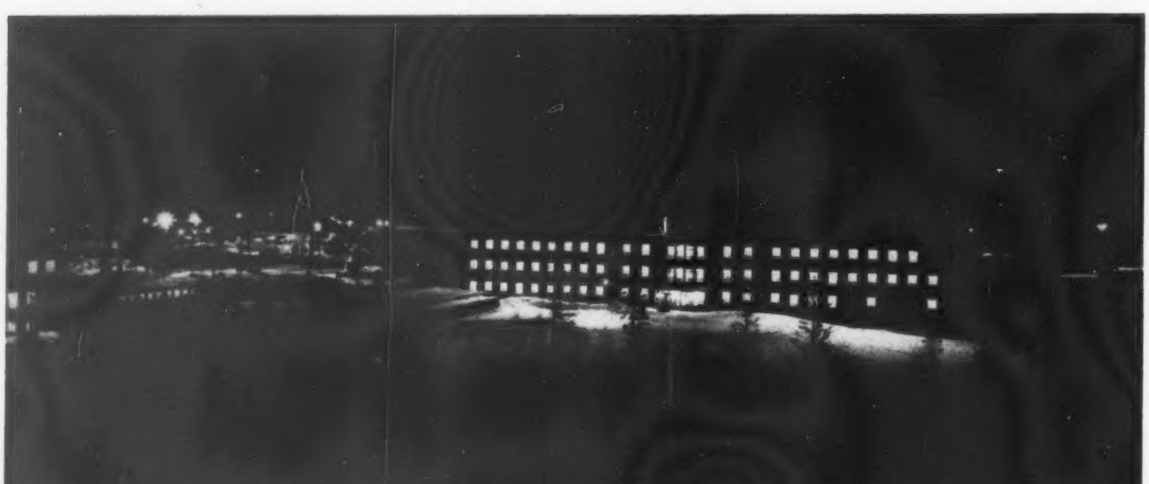
Organization

The company is organized with due regard to the two spheres of activities described here, mining and smelting. The centre of the mining department is Boliden, where prospecting, mining, concentration of the ores, and mining and refining research are organized. The Rönnskär Works, which is responsible for the production of metals and chemicals, the chemical, physical and metallurgical research, is administered independently. The managing-director of the company is stationed in Stockholm, where the general administration of the company, and the sales and buying department are situated.

The total number of people employed by the company is about 4,600, of which 1,200 belong to the administrative staff. The majority, or 2,650, are employed by the mining department, while the Rönnskär Works employs about 1,850.

Finally, a few words about production, which has shown an almost unbroken increase since the start. The annual output of copper is at present about 40,000 tons, and of lead about 37,000 tons. The production of silver is around 100,000 kg., and of gold about 4,500 kg. Further, an annual production of 40,000 tons of sulphuric acid may be mentioned.

The central laboratories of the Boliden Mining Company



Works Visit

Liljeholmens Kabelfabrik

By GUNNAR AXELSSON

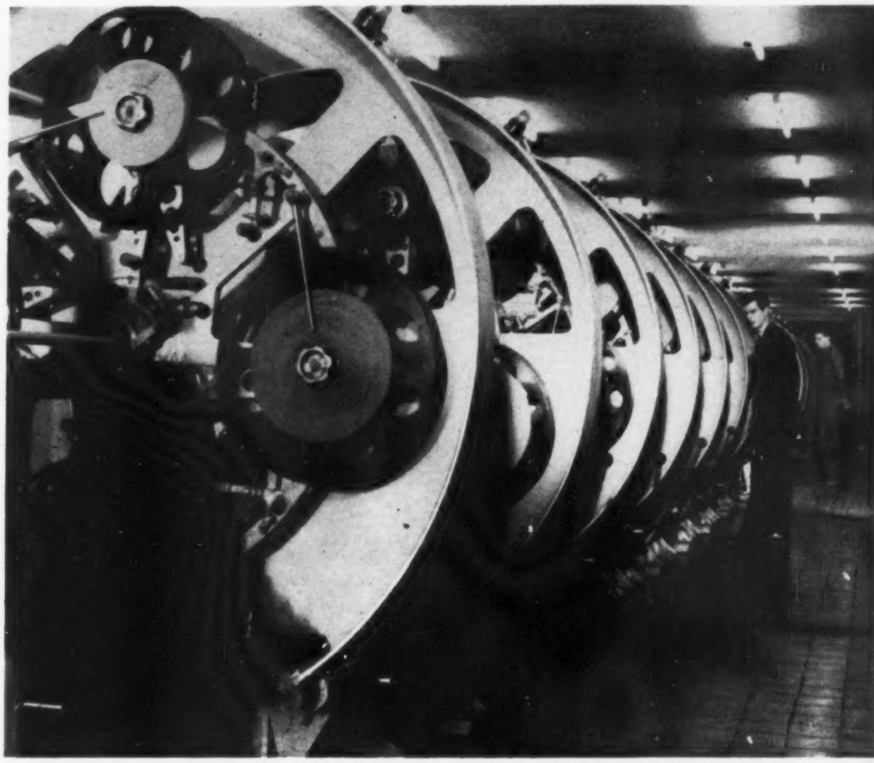


Fig. 1—Paper-taping machine for high-voltage cables

CELEBRATING its 90th anniversary next year, Liljeholmens Kabelfabrik is situated in one of the suburbs south-west of Stockholm. Originally a private undertaking, it was in 1901 converted into a joint-stock company. In 1916, the Allmänna Svenska Elektriska Aktiebolag (ASEA) acquired the majority of the shares, and since that time the factory has been part of the ASEA group.

Until 1930, production consisted almost exclusively of rubber-insulated wires and cables, but in that year a new and larger factory was built and equipped for the production of a wider range of cables, as well as of capacitors, for every voltage and purpose within the power field.

The development of the works, since the building of the new factory, has been rapid. A steadily increasing annual turnover plus the rise of new products have resulted in several extensions to the new works, so that the total floor space today is 467,000 ft^2 (43,400 m^2) and the number of employees approximately one thousand.

The present production programme comprises:

(a) Wires and cables insulated with natural or synthetic rubber, polyvinyl chloride or polyethylene;

(b) impregnated-paper power cables for voltages up to 425 kV. (As early as 1950, the company delivered its, and the world's first 425 kV cables.);

(c) power cables insulated with polyvinyl chloride;

(d) cable end boxes and cable joint boxes; and

(e) capacitors for power factor correction.

In the production of cables, much attention is given to the achievement of continuous processes which give a higher and more even quality than do the older methods. Many of these processes were pioneered at Liljeholmen, and among these special mention may be made of the Liljeholmen continuous lead extruder (also known as the Hansson press), methods for continuous insulating and vulcanizing of rubber cables, continuous annealers, and the tandem operation of such continuous processes.

Liljeholmen today uses copper as the sole material for the conductors. The copper is bought from an ASEA affiliate, Elektrokoppar, located in Hälsingborg, Sweden, in the form of wire rods which are then drawn down to the necessary dimensions. The annealing procedure goes on continuously, as the wires are passed through electrically heated steel pipes, or through direct heating of the wires by means of an electric current, the annealing process thus taking only a fraction of a second. The heavier cores, which consist of a number of untinned wires built into round or sector-shaped conductors, are also continuously annealed in the stranded form by means of an electric current sent through the conductor. This treatment softens the conductor and thus provides for a very good flexibility in the finished cable. This flexibility is especially important when the cores are compacted subsequent to stranding.

The factory's production of insulated wires and cables includes all kinds of wiring material for power and lighting. Natural rubber, earlier the only insulating material used for these purposes, has now been replaced, above all by polyvinyl chloride (P.V.C.), but also by different kinds of synthetic rubber and by polyethylene. Of the synthetic rubbers, those mainly used are neoprene, butyl rubber and silicone rubber. Since these materials all have different properties, it is possible nowadays, to choose the cable according to the strains to which the cable will be exposed. All these insulating materials are applied by means of extruders which, per machine, have a production capacity of 100-500 metres per minute of rubber or P.V.C. insulation. The rubber-insulated conductors are continuously vulcanized in long steel pipes directly connected to the extruders. These pipes are filled with high pressure steam for heating the insulating material round the conductor, and during the rapid passage through the pipe the rubber is vulcanized.

A part of the production of P.V.C.-insulated wires is consumed by Liljeholmen's department for the manufacture of complete wiring nets (harnesses) for motor-cars. The products of this highly specialized manufacturing programme are delivered to the Swedish motor-car industry.

Another speciality in wiring material is flexible electric cords insulated and coated with rubber or P.V.C. These cords are delivered in short lengths, fitted up with connecting devices, and ready for use as connection cords for flat-irons, kitchen apparatus, and the like.

Power cables insulated with impreg-

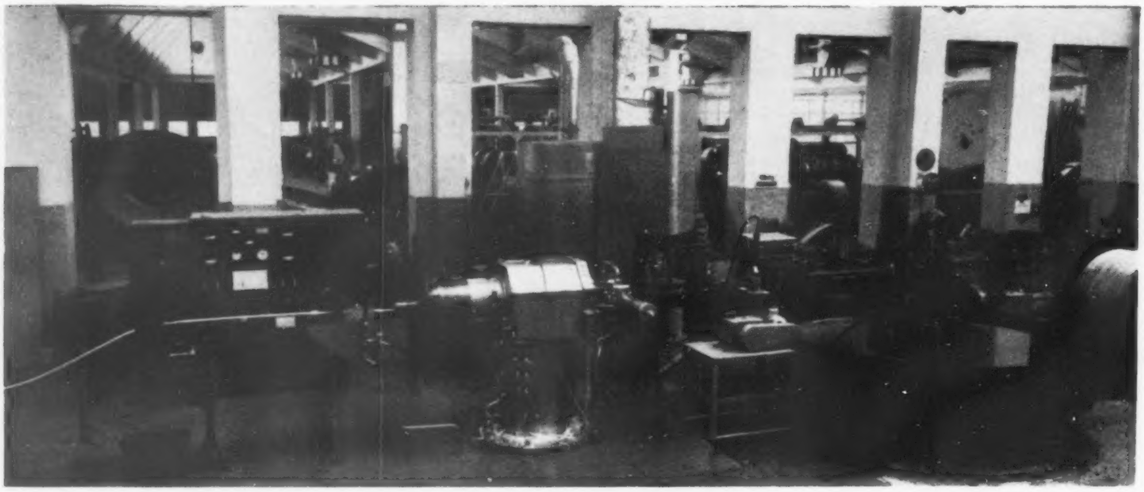


Fig. 2—Machine for continuous lead extrusion

nated paper are produced for all voltages up to 425 kV. Most of these, up to 30 kV, are cables of the belted type, and are impregnated with a thick mineral oil. The insulation consists of high quality paper which is applied in tape form (Fig. 1), after which the moisture in the paper is removed in heated vacuum tanks. The drying process is accelerated by means of an electric current which is allowed to pass through the conductors and heat the cable from the inside. The dried insulating material is then impregnated with a mineral oil. The next step is the extruding of a lead sheath round the cable. For lead extruding Liljeholmen has developed the continuous extruding machine mentioned earlier in this article (Fig. 2). This extruder, which has, to a large extent, replaced the earlier, conventional piston presses, has won a world reputation and is now used in many of the leading cable works throughout the western world. The soft lead covering must be protected, and the cable is therefore provided with armouring which normally consists of asphalt, tapes of paper or cotton, jute, and tapes of steel or steel wire.

A pioneering venture of the company, as regards cables impregnated with thick mineral oil, is the 100,000 V direct current submarine cable from the Swedish mainland to the island of Gotland. This 62 mile long (100 kilometre long) cable constitutes the first instance of high voltage D.C. power transmission in the world. Many years of research and planning preceded the actual construction of the cable, which now carries to Gotland the island's entire supply of electricity.

The general run of power cables for voltages higher than 30 kV are, however, constructed by Liljeholmen in a somewhat different way, viz., as oil-filled cables. They are, of course, insulated with paper but are also filled with a very thin oil which moves along the cable through channels in the conductors or between the laid up cores, thus keeping the cable oil-filled at all times. The oil is under a pressure of about 28 lb/in^2, this pressure being maintained by means of feeding tanks connected to the cable.

The company's first oil-filled cables were designed to carry 150 kV and were delivered in 1940. The second world war delayed further development, but in 1948 the company manufactured and installed cables for 220 kV, and two years later took the step to 380 kV, delivering at this time a number of cables for this very high voltage. These cables have been in service since 1952. The extension of the main transmission lines in Sweden, however, required cables for still higher voltages, with the result that Liljeholmen produced the world's first cables for the transmission of 425 kV. These oil-filled cables were put into service in 1955.

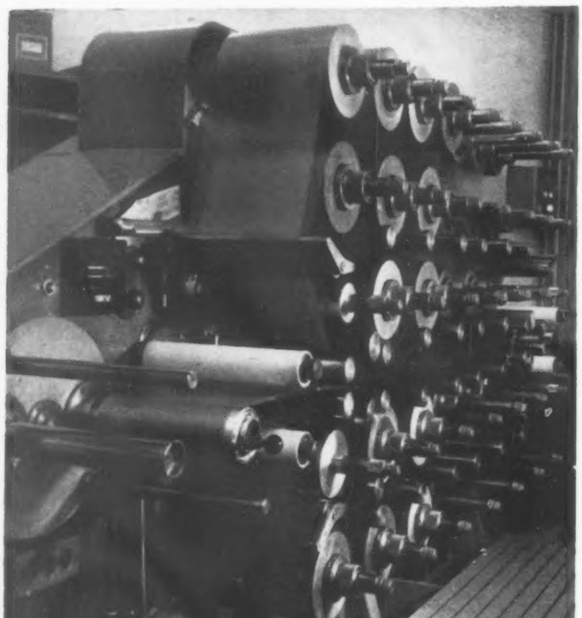


Fig. 3—Capacitor winding machine

P.V.C.-insulated power cables for voltages up to and including 10 kV are now taking a larger and larger part in the company's manufacturing programme, and the rapidly increasing demand for such cables during 1958 has necessitated a conversion of the factory's machinery. These cables are, as a rule, built up entirely of copper and a P.V.C. compound. They have no lead sheath and, normally, no armouring. All P.V.C. is applied by extrusion. The insulated and laid up cores are surrounded by a layer of flat or round

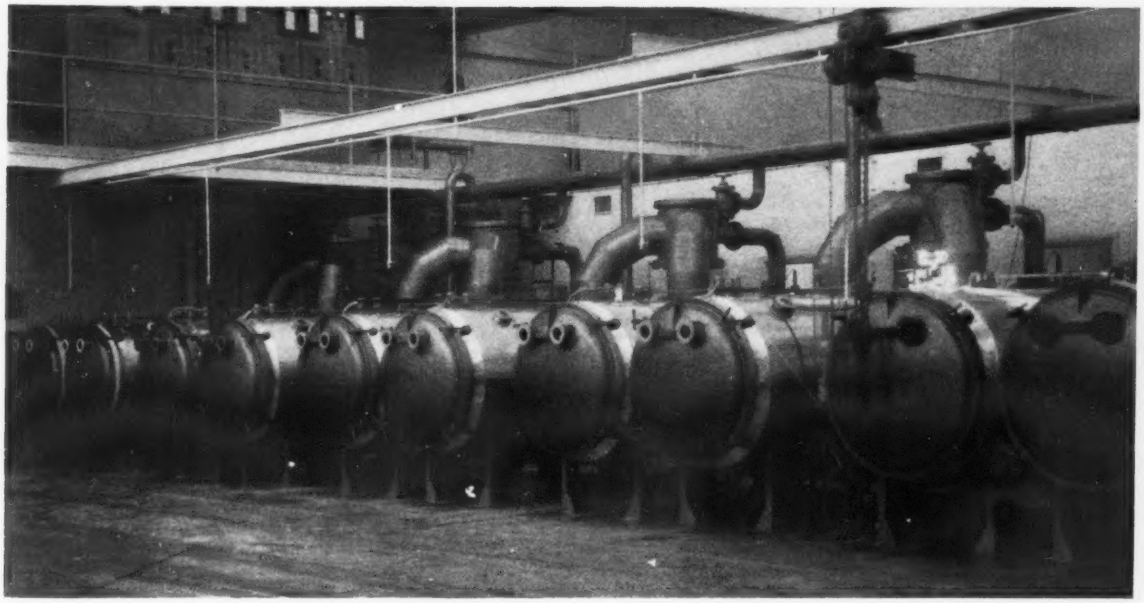


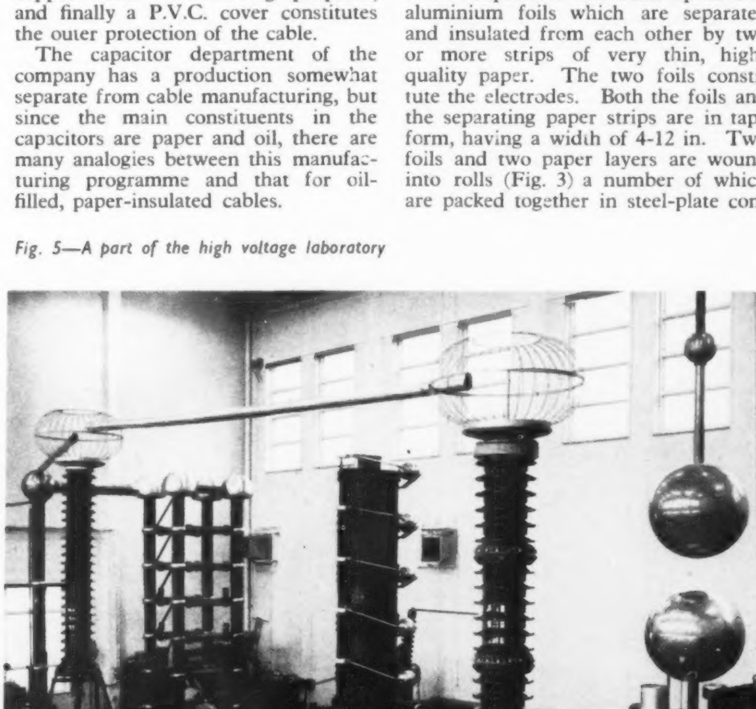
Fig. 4—High vacuum drying tanks for capacitors

copper wires for earthing purposes, and finally a P.V.C. cover constitutes the outer protection of the cable.

The capacitor department of the company has a production somewhat separate from cable manufacturing, but since the main constituents in the capacitors are paper and oil, there are many analogies between this manufacturing programme and that for oil-filled, paper-insulated cables.

The capacitors are built up of two aluminium foils which are separated and insulated from each other by two or more strips of very thin, high-quality paper. The two foils constitute the electrodes. Both the foils and the separating paper strips are in tape form, having a width of 4-12 in. Two foils and two paper layers are wound into rolls (Fig. 3) a number of which are packed together in steel-plate containers. The latter are supplied with bushings for the electrical connection to the foils. The containers are put in high-vacuum tanks (Fig. 4) after which, thanks to holes which are still open in the containers, the paper can be dried and then impregnated with thin oil of the same quality as is used in the oil-filled cables. After this procedure, the containers are sealed and pumped up with oil to an overpressure. The design combines (1) means (i.e. the flexible steel walls of the container) for maintaining a high oil pressure, in order to increase the dielectric strength of the paper; and (2) a special method of cooling which keeps the capacitors cool despite heavy loads. The capacitors are, as a rule, used for power factor correction. A particular speciality for the company is large batteries of capacitors for series installation in 220,000 and 400,000 V overhead lines, in order to increase the transmission capacity of these lines.

Fig. 5—A part of the high voltage laboratory



The factory's production requires a thorough control both of the raw materials used and of the out-going, finished products. Since the company has ventured into such new fields as that involving the highest voltages ever used for cables, extensive research on new raw materials and designs must be given a paramount position in the production programme. For these purposes, the company has testing departments in various parts of the factory and a well-equipped laboratory with departments for chemical, mechanical and electrical testing. The high voltage department of the laboratory has a floor space of 6,450 ft^2, and its equipment includes such items as a 600 kV transformer, a 2,800 kV impulse generator and a 1,200 kV direct current rectifier (Fig. 5).

L. M. Ericsson Telephone Company

BOTH a manufacturing company and a holding company, the L. M. Ericsson Telephone Company controls forty-seven subsidiaries in which it owns more than a 50 per cent interest, thirty-six of which are located outside Sweden. The company also has substantial interests in 10 associated companies, all of which are outside Sweden. Of its 31,000 employees, about 14,000 work in Sweden. More than 9,000 are in the parent company, where they are chiefly engaged in the design, development and manufacture of all kinds of telephone equipment.

The principal production facilities available to the group are the parent company's eleven plants in Sweden, of which six are located in the Stockholm area and five in other parts of Sweden. These factories produce mainly telephone instruments and exchanges, automatic and manual, equipment for carrier-frequency telephony and telegraphy, telephone repeaters, equipment for voice-frequency signalling systems, transmission material, line transformers, loading coils, line material, all kinds of cable and wire, telephone answerers, tape recorders, equipment for fire-alarm systems, fire-alarm telegraph, time recording and signal apparatus and electric clocks.

Supplementing the Swedish plants of the parent company are eight plants of the Swedish subsidiaries: Sieverts Kabelverk AB produces mainly power and telephone cables and various types of wire, as well as cable accessories, lighting fixtures and capacitors. Svenska Radio AB's manufacturing programme includes commercial radio equipment and radio and television sets.

Bakelite and plastics parts are supplied by AB Alpha principally to the Group's Swedish factories. It also manufactures electric installation hardware, hydraulic moulds and testing machines, as well as record presses, which are in particularly great demand on the export market.

Capacitors are produced at AB Rifa, chiefly for group factories in Sweden, and also sold to other domestic customers. AB Ermi manufactures electricity meters of various kinds, and AB Svenska Elektronrör supplies the group's domestic factories with electronic tubes. AB Ermex manufactures electric fences and high-quality locks.

Abroad, L. M. Ericsson has twelve plants, situated in seven countries: Denmark, Finland, France, The Netherlands, U.S.A., Argentina and Brazil.

Midsommarkransen, a Stockholm suburb, is the site of the main plant, laboratories and the group's administrative headquarters. The modern technical resources of this plant, containing about 1,250,000 ft^2 of floor space have been utilized to the full in order to achieve effective production.

One of the problems peculiar to the L. M. Ericsson operations is the importance of turning out precision-engineered equipment that will operate dependably under the most rugged conditions and for lengthy periods in many parts of the world. The test laboratories in Stockholm regularly duplicate the hot, moist atmospheric conditions of jungle climates (a large L. M. Ericsson exchange has been operating in the Amazon jungle with exclusively native maintenance for more than 20 years) and the subzero temperatures found above the Arctic Circle (where L. M. Ericsson has a number of installations).

In the main, emphasis, of course, is on telephony. The dial telephone system employing 500-line selectors is perhaps the most outstanding of the Ericsson products. The first exchange equipped with this system was opened in Stockholm in 1923. Public and private exchanges serving more than 3,000,000 lines have been installed since then.

The automatic telephone exchange equipment has been the subject of continuous study. One result has been the development of the Ericsson crossbar systems. With an almost complete absence of mechanical moving parts, these systems replace sliding contacts by precious-metal pressure contacts. Thoroughly reliable in operation, they have reduced maintenance requirements to a minimum. Automatic telephone exchanges equipped on this system are much in demand. Orders have been received from all continents and now total 1,000,000 lines.

The company has long been engaged in producing equipment for carrier telephony, that is, telephone systems which permit many simultaneous calls on one circuit. Progress has been very rapid in this field during recent years. Using coaxial cables, 960 simultaneous conversations can be carried on the same cable circuit. Many other kinds of modern equipment are produced for long distance communications such as: programme channels for transmitting broadcasting programmes from studios to transmitter stations, radio links, telegraph systems, etc.

Passing over to another form of enterprise, the tower at the company's main plant (237 ft. in height) is used for experimentation on very high frequency (VHF) or microwave transmission. Ultra short waves are beamed between stations 25 to 50 miles apart.

A recent Ericsson development has been the design of an "intercom" switchboard that almost "thinks". Through the use of crossbar switches and relays, the equipment's "relay brain" memorizes numbers and completes calls by itself, traces and locates executives who have left their desks, and permits emergency interruptions of routine conversations.

Works Visit

Wedaverken

AB W. Dan Bergman

WAY back in 1915, W. Dan Bergman, a Swedish civil engineer, whose experience in the United States had fired him with the idea of going into light metals production in Sweden, established a magnesium plant at Trollhättan. The bulk of its production was exported, with Czarist Russia as a leading buyer; however, the onset of the Russian Revolution soon put an end to this trade. Although the Swedish market at that time was quite negligible, Mr. Bergman never lost faith in the possibilities of a domestic light-metals industry concentrating on cast products. At Trollhättan he had worked out experiments on a number of alloys. In order to find applications for them, a foundry was set up at Södertälje in 1919. During its first ten years the foundry was run on a very modest scale: the labour force ranged from two to four men, and annual sales amounted to some 10,000 kronor. In those days, the light metals found only a meagre market among Sweden's machine shops and engineering plants.

Business started turning for the better in the middle of the 1920's, the labour force was enlarged to ten men, and with the appearance of the Volvo Automobile Company as a customer the sales curve, too, started to climb.

It was in 1931 that the Nohab firm launched the manufacture of Swedish designed aircraft engines, and that year may be designated as the date when light metals came to Sweden to stay. The company became the authorized supplier of light metal castings for the Bristol engine, and about the same time the sole domestic rights to the manufacture of "Elektron", "Hydronalium" and "Hiduminium" alloys were acquired from I.G. Farbenindustrie and High Duty Alloys Ltd.

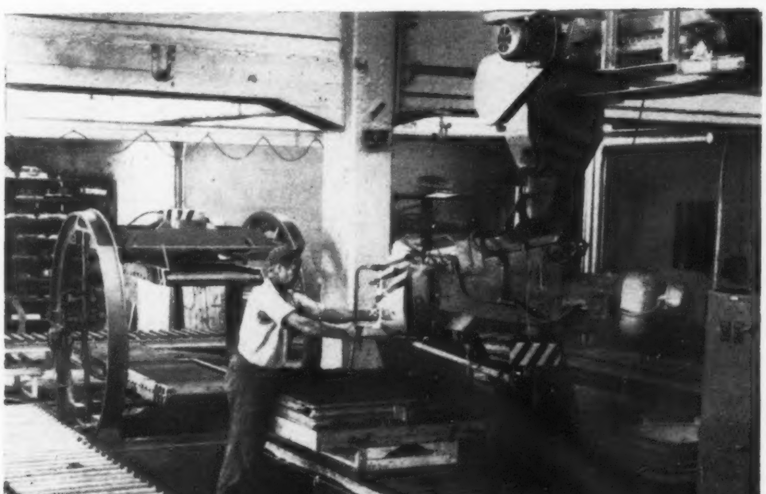
The stage was thus set for long-term growth, which now proceeded at an accelerated pace. In 1935, the firm of W. Dan Bergmans Aluminium—och Metallgjuteri, as it was then called, employed a labour force of up to 25 men and total sales were in the neighbourhood of 500,000 kronor per year.

The present factory site was acquired in 1936. Thanks to the licensing arrangements with I. G. Farbenindustrie and High Duty Alloys Ltd., the company's light metal castings were able to penetrate into more and more fields. A new casting department was ready for service in 1938, but new enlargements to plant had to be made the very next year. After another year, a new magnesium foundry had virtually doubled production capacity. The labour force now numbered some 100 men and total sales were in excess of 2·7 million kronor.

In 1939, AB Bofors, which had fully realized the great importance of light metals for the future, acquired the firm which was reorganized as Aktiebolaget W. Dan Bergman.

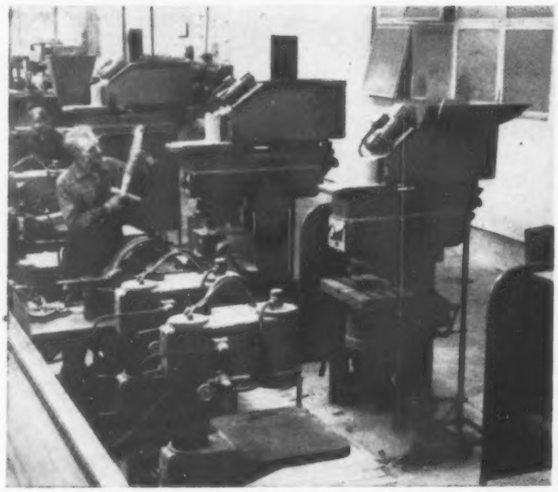
Developments moved apace in the 1940's, spurred in great measure by central-government orders. When the authorities called in 1942 for stepped-up manufacture of domestic aircraft engines, the inevitable result was to force large-scale expansion on Wedaverken, as the company was then beginning to be called. New wings and buildings were completed in 1943, at a total cost of more than 2,000,000 kronor, and were put to immediate use. The introduction of press-forging in the same year, required the installation of two special presses of 250 and 600 tons capacity. A new department for the die-casting of aluminium, magnesium and zinc alloys came in 1945, and 1947 finally witnessed the opening of an extrusion plant for making bars, tubes and sections in light metal. As the result of an extensive construction programme, carried out from 1946 to 1958, most of the workshops described here have been rehoused in fully modern premises.

Sand slinger for medium and large moulds



Lef: The magnesium foundry at Wedaverken

Below: Milling die block for pressure die-casting



Left above: Core making department for CO_2 cores

Left: The extrusion department with 1,200 ton Loewy press and Birlec induction billet heater

Today, the Wedaverken factory includes eight production departments, in addition to the auxiliary services and the office, which consists of the Administrative, Sales, Control and Research divisions.

The aluminium and magnesium casting departments are wings of the office building. The pressure and gravity die-casting departments are located in a building completed in 1948. The extrusion department, projected in 1945, was ready for production in its own building in 1947. The machine shop, formerly one of the auxiliary departments, was installed in its own building in 1946. The core department, erected in 1957, is located between the two foundry wings.

The aluminium casting department, which is the oldest part of the factory, continues operations in the first building to be put up on the present site. This building has been enlarged and completely renovated, the last such improvements having been made in 1959. Machine-moulded production articles and hand-moulded special work are made here. There are four small jolt-squeeze moulding machines, four large Tabor jolt-rollover machines, and one Webac automatic.

Medium-sized and large moulds are prepared on a sand-slinger line. There is also a small hand-moulding section. The melting equipment includes eight crucible furnaces of various types and three low-frequency induction furnaces ranging from 1,100 to 2,200 lb in capacity. The melting furnaces produce about 2,000 tons of hot metal per year, 1,000 tons of which is continuously cast. The chief aluminium alloys used are "Hiduminium" "Silumin-Gamma," "Wedal" and Hydronalium."

A small shell-moulding section is used primarily to make cores for gravity castings.

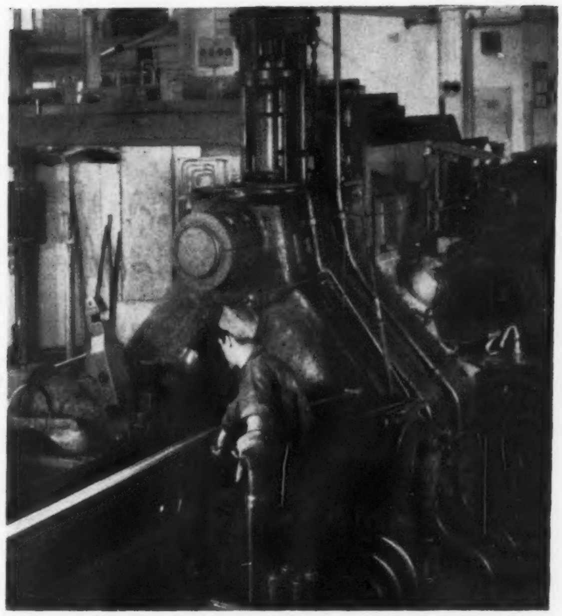
The largest casting poured at Wedaverken weighed about 2,000 lb. after finishing (3,100 lb. of metal poured). Castings as small as $\frac{1}{4}$ of an oz. net weight are also made. The average weight of castings produced in quantity is about 3 lb., and the average weight of hand-moulded castings is about 20 lb.

The aluminium casting department has 75 employees, 70 of whom are labourers, casting operators, machine moulders, coremakers, shakeout men, furnace operators, and the like. Also located in this department are a 600 ton and a 250 ton forging press.

The magnesium casting department is also divided into machine-moulding and hand-moulding sections. Here, as in the aluminium department, both single castings and quantity products are cast. With the melting capacity now available, magnesium castings up to about 1,100 lb. are produced.

Forty-five men are employed in the magnesium casting department.

The core department was modernized about one year ago. The CO_2 method was introduced on a large scale, and coremaking is now centralized in one department, where about 60 per cent of the work is done by the CO_2 method.



The 1,200 ton Loewy extrusion press

Carbon dioxide is piped to every working place from a central tank with a capacity of 2·5 ton. Most cores are blown. The equipment also includes four Röper-Werke core machines.

Most of the cores are cured in machines with automatic controls. The core department has fourteen employees.

The pressure die-casting department, located in a building of its own since 1948, has a pouring floor with fourteen medium-sized casting machines and a trimming, deburring, and machining section. Aluminium alloys similar to the American alloys number 360 and 380, and Zamak 5 zinc alloy are cast here.

A small gravity-casting section is also housed in the same building as the pressure-casting department. The metals are mixed and melted in five 440 lb. melting furnaces, which supply the electric holding furnaces from which both the pressure-casting and the gravity floors receive their metal. The pressure-casting department has 50 employees.

The extrusion department is equipped with a 1,200 ton Loewy extrusion process and two drawing machines for bars and tubes. There are also stretcher levellers, roller levellers, and sections for pickling, degreasing, and heat-treatment.

Two induction billet heaters were put into operation early in 1959. The heaters operate independently of each other on a 6,300 V, 50-cycle supply. Each heater draws 300 kW. The overall output is 50 aluminium billets per hour (billet size 6 in. in diameter, 27·6 in. long). The billets are brought from room temperature to 1,110°F. in 140 sec.

The extrusions consist of tubes, bars, and sections of aluminium. Most of the output is for building and engineering construction. Twenty men are employed in this department.

The two principal sections of the machine shop are the toolroom and the section machining castings and forgings. The toolroom makes gravity and pressure dies, drawing dies, extrusion dies, jigs, and fixtures. The other section machines custom castings and forgings, and also makes some machined products of its own.

The machine shop is equipped with some 60 machines of the most modern type. The building and the machines are well lighted and "colour-conditioned." About half of the 80 men in this department are employed in the toolroom, the other half in the machining section.

Laboratory facilities for control and research, include departments for chemical, spectrographic, metallographic, metallurgical, and mechanical testing and investigation. The most recent acquisition is a 1·5-metre ARL quantometer, made in Switzerland under American licence.

The chief business of the laboratory is research and running control of quality. As a supplier to the Swedish Air Force, Wedaverken must meet the rigorous standards maintained for aircraft materials. About 70 per cent of the capacity of the laboratory is engaged in this important task.

The laboratory has a staff of fifteen, about half of them being technical personnel.

Wedaverken's products include circulating pumps for heating systems, and submersible drainage pumps, distributed outside Sweden through Svenska Motorborr A.B., of Stockholm, in several sizes and types. A hydraulic fork-lift truck in light metal alloy is now in production also. Collapsible containers made of plywood panels and aluminium frame members, are made under licence from the Warwick Production Co. Ltd., of Warwick.

Swedish Non-Ferrous Metal Industries

By O. NYSTEDT

(Head of Sales Statistics Department, AB Svenska Metallverken, Västerås)

ALTHOUGH Sweden is notably rich in iron-ore deposits, it has other metals in important quantities, among them copper and zinc. Copper was mined in Sweden long before the modern industrial period, and the central Falun mines were a main source of Sweden's not too remarkable prosperity during the "Great Power period" of the 17th and 18th centuries. It is estimated now that about 450,000 tons of copper must have been extracted from the Falun fields—and if that was insufficient to keep Sweden off the verge of bankruptcy during her warlike enterprises, she was, at any rate, without comparison the world's largest copper producer, and a producer of copper coins so large that they had to be pushed around in barrows!

Copper production at Falun has now stopped, the modern exploitation centre having shifted to the more recently "discovered" north of Sweden. The only copper mines exploited now —for more modern purposes than copper coins and decorative bronze cannon—are in the Skellefteå fields, as they are called (although some, with reference to the gold struck there, call them more romantically "Sweden's Klondike"). Boliden itself gives its name to the now famous company.

The deposits at Boliden were discovered as late as the middle of the 1920's, and the first copper, silver, gold and lead refinery was started up at Rönnskär, just outside the port of Skellefteå, in 1930. Zinc also was struck in the Skellefteå fields, but unlike other non-ferrous Swedish ores it is exported to industries abroad enjoying better access to coal and cheaper electrical power facilities than those so far available in Sweden.

The contrary is the case with aluminium, which is refined in Sweden from imported oxides, including Norwegian, by AB Svenska Aluminiumkompaniet, generally known as SAKO.

Copper production at Bolidens Smältverk at Rönnskär increases. During the period between 1948 and 1958, it increased by over 40 per cent, reaching an output of 34,000 tons, the highest annual production so far. A new electrolytic plant, recently completed, should permit an annual production of 40,000-45,000 tons of refined copper. The percentage of Swedish copper used industrially in Sweden also increases, as the following figures show:

	1948	1957
Swedish production of refined copper, 1,000-tons	24·1	32·9
Swedish consumption of refined copper, 1,000-tons	57·3	66.6
Ratio of production to consumption, per cent	42	49

Producing aluminium, SAKO has refineries at Månsbo, near Avesta, and at Kubikenborg, near Sundsvall, on the Baltic. The Avesta factory, built in 1934, at present produces 2,000 tons annually. The larger Kubikenborg factory, opened in 1943, has a present annual capacity of 13,000 tons. As with copper, Swedish aluminium production accounted in 1957 for just short of one-half of domestic manufacturing needs, but that is a considerable step ahead from 1948, since when production of the refined metal has been quadrupled, and its percentage use in the growing Swedish aluminium manufacturing industry doubled, as is shown below:

	1948	1957
Swedish production of refined aluminium, 1,000 tons	3·7	13·6
Swedish consumption of refined aluminium, 1,000 tons	13·3	28·8
Ratio of production to consumption, per cent	25	47

Aluminium consumption in Sweden in 1956 amounted, *per capita*, to 4·20 kg., against 6·68 in U.K., 4·98 in W. Germany, 3·42 in France, and 10·71 in U.S.A.

Semi-Manufactures

The largest Swedish producer of metal semi-manufactures is AB Svenska Metallverken which, with works at Västerås, Finspong and Granefors, traces its origin to the seventeenth century. Its range of non-ferrous production includes sheet and plate, strip, foil, wire, cable (for electrical purposes), tubes, bars and sections, in copper, aluminium and their alloys. In 1958, Svenska Metallverken accounted for about 70 per cent of total Swedish production of copper and copper-alloy semi-manufactures. About 97 per cent of Swedish aluminium semi-manufactures come also from Svenska Metallverken —wire and cable from Västerås and pressed and rolled goods, including foil, from Finspong. The foil works at Finspong will soon be closed, to be replaced by a new foil works at Skultuna, which should be in production some time during 1960.

Other Swedish concerns producing semi-manufactured non-ferrous metal

TABLE I—SWEDISH NON-FERROUS METALS

	1957	1958			
	Consumption	Consumption	Production	Import	Export
Aluminium and Aluminium Alloys					
Wire	3·8	5·4	12·2	0·1	6·9
Sheet and plate	16·3	18·6	12·8	6·5	0·7
Bars and tubes	2·9	2·8	2·0	0·9	0·1
	23·0	26·8	27·0	7·5	7·7
Copper					
Wire	29·2	30·1	47·6	0·3	17·8
Sheet and plate	4·1	5·4	9·9	1·1	5·6
Bars	0·9	1·3	1·8	0·2	0·7
Tubes	7·2	8·1	8·1	2·1	2·1
	41·4	44·9	67·4	3·7	26·2
Copper Alloys					
Wire	2·2	2·3	2·2	0·4	0·3
Sheet and plate	11·8	10·0	11·2	0·3	1·6
Bars	14·0	13·9	13·6	0·7	0·4
Tubes	4·6	4·8	5·3	0·4	1·0
	32·6	31·0	32·3	1·8	3·3

All figures are given in thousands of tons.

wares, include notably AB Elektrokoppar at Hälsingborg on The Sound, which opened a new aluminium wire factory in 1958, and which, together with Svenska Metallverken, accounts for the entire Swedish production of aluminium wire.

AB Gusums Bruk and AB Södertälje Metallförädling produce brass semi-manufactures, and AB W. Dan Bergman & Co., also of Södertälje just south of Stockholm, produce mainly aluminium semi-manufactures — bars and shapes.

Non-ferrous metals are cast at a large number of foundries throughout the country. Some are connected to consuming industries, others are independent. The domestic output in 1957 was 18,000 tons copper and copper alloys and 6,000 tons light metals.

Freedom from import restrictions and comparatively low import duties give rise to keen competition to Swedish non-ferrous semi-manufactures on the home market, which accounts also for relatively high imports to Sweden. Exports, however, are considerable, with the other Nordic countries still as the main market, although lately exports to countries outside Scandinavia have come to take a more and more important place.

A general idea of the production, consumption, and trade positions is given in Table I.

FOUNDATION FOR FUNDAMENTAL METAL RESEARCH IN SWEDEN

Metallografiska Institutet

By Prof. E. RUDBERG

IN its present form Metallografiska Institutet, the Swedish Institute for Metal Research, dates back to 1943. The name in English conveys a more adequate picture of its field of activity than does the official Swedish designation, which for historical reasons was retained from its predecessor. The older laboratory with that name was founded in 1920, under the directorship of Professor Carl Benedicks, in close connection with the University of Stockholm. It was financed chiefly by grants from industry, especially through the Swedish Ironmasters, Jernkontoret. Under its first director and through men like Westgren, Phragmén, Hägg and others that older institute contributed much of the internationally recognized, pioneering research, particularly on alloy structure.

The plans for the Institute of 1943 are contained in an agreement between the Swedish Government on one hand and an industrial body, the Foundation for Steel and Non-ferrous Metal Research, on the other. They follow a pattern adopted in the creation of similar laboratories in other industrial fields, such as wood products, textiles, food preserves—laboratories sponsored jointly by government and private industry. In this case the Government agreed to erect a suitable building, maintain it, and defray its costs for heating. The Foundation promised to furnish research equipment, and to provide an annual sum for salaries and other expenses. For this grant, a certain minimum amount was fixed: the present yearly contribution from the Foundation (£50,000) is more than four times the stipulated minimum.

The three main partners in the Foundation are Jernkontoret, the Mechanical Industries Association and the Non-ferrous Metal Industries Association—each one mustering as members, practically all Swedish industrial firms in its field. The Governing Board of the Institute is comprised of elected representatives from these organizations, and three members chosen by the Swedish Government.

Building difficulties during and after the war, delayed laboratory construction till the end of 1947. Since that time the Institute has had the use of a main laboratory unit in three stories, with about 2,000 m^2 floor space, and an adjoining furnace hall of about 500 m^2, chiefly for work with heavier equipment. The two units are connected through an underground passage-way.

According to its statutes, the Institute should devote its efforts chiefly to investigations on problems of a fundamental nature in the field of metals—ferrous and non-ferrous. Work belonging to the general research programme, which constitutes the main part of the activity, is frequently planned and discussed in small committees, with members from the industrial groups concerned within the Foundation. The results are published as reports and Papers, in *Jernkontorets Annaler* and in the leading international journals, mostly English or German.

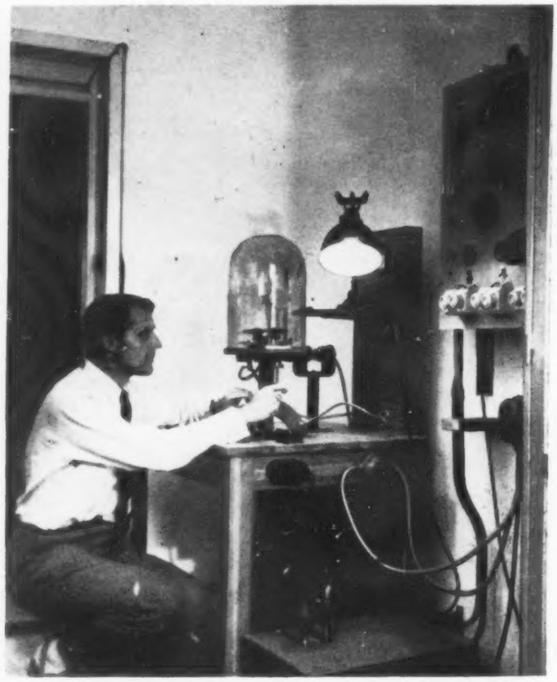
Apart from its main investigations, the Institute also undertakes studies and gives consultant service on particular problems, at the request of private industrial firms or government departments. The fruits of such sponsored work become the property of the client, to whom also the costs are charged. In recent years, such items have amounted to 10-15 per cent of the Institute's total expenditure.

Methods of rapid and accurate quantitative analysis of metals play an important part in the metal industry today, and they occupy a corresponding place on the Institute's research programme. The Chemistry Division has concentrated its efforts on the development of spectro-photochemical methods for the determination of small amounts of certain metals in solution. As usual, such work involves getting rid of, or else holding under control, the various other chemical elements which are ordinarily present in considerably larger quantities in the technical alloys concerned and which, if unchecked, would seriously distort the results. Efforts have been devoted to the analysis of small amounts of aluminium in steel—applicable in some methods for evaluating oxygen from oxidic slag inclusions—of boron in steel, in cast iron and in aluminium, and of cobalt, especially in alloy steels. The Division for Spectrochemical Analysis has, from the Institute's early years, worked out and developed most of the important tools of emission spectroscopy employed in Swedish steel mills today. These include photographic methods as well as the more recent direct reading ways of registering spectra. The leader of this work at the Institute, C. Georg Carlsson, has organized a discussion group with members from most industrial laboratories interested in such methods, which group meets regularly at the Institute for mutual information. A third line in the chemical analysis field may be said to concern the determination in metals of such constituents as come out in gaseous form—oxygen, nitrogen, hydrogen. Much effort is being devoted to improving the methods of oxygen determination, mainly in steel, through vacuum fusion and reduction by graphite. Certain accompanying elements, of critical volatility, are liable to interfere seriously with the quantitative yield of oxygen as carbon monoxide, notably when low oxygen contents are concerned. A similar difficulty presents itself in the determination of hydrogen, for which special methods have been studied at the Institute.

The hydrogen work is linked to investigations of a wider scope. The mechanical properties of steel, as influenced by hydrogen content (brittleness) and, associated with this, the readiness of the material to pick up hydrogen in various technical processes, have all been studied. The diffusion of hydrogen through the metal comes in under this line of work, too. Of a rather more fundamental nature is some work, recently carried out, on the hydrogen solubility at high temperature in the iron-chromium-nickel system.

Of a very different nature are the efforts at the Institute to contribute to the knowledge of corrosion phenomena.

Vacuum fusion apparatus for determination of hydrogen content



Preparation of replica film by evaporation, to be examined in the electron microscope

Atmospheric corrosion of a number of commercial aluminium alloys is studied through exposure tests at certain field stations, located to give typical environments and climates — marine, inland, industrial. The exposed material is inspected at regular intervals, and specimens are removed to the laboratory for various tests, in accordance with a long-term programme.

A fairly wide group of problems tackled at the Institute concerns foundry work. On the non-ferrous side, this has involved studies and efforts for control of oxide content in aluminium alloys, and research on the action of a number of grain refining additions to light alloy castings. Control of the various factors which are involved in making pressure-tight bronze castings is another item. It would leave too big a gap here to omit from mention the extensive work on foundry sand, and on mould materials and mould problems, notably for steel castings, in which the Institute has engaged. Systematic investigations on metal penetration into the mould wall, studies of peeling, of the mechanism of the cooling exerted by the mould on the hot metal, have contributed, it seems fair to say, notable improvements to foundry methods.

A metallographer's classical tool is the microscope. Much of the Institute's work, on more short-range practical problems as well as on fundamental research projects, involves such structure studies. They span a very wide field of different metals, as would seem appropriate under the terms of this Institute. Of fundamental nature are studies on the micro-structures of carbon steels that result from heat-treatment, conducted as isothermal transformation. Quench technique is used to interrupt the solid state reaction at predetermined points in the process. Microscopic examination, electron microscopy on replicas, and studies on the fine precipitates isolated by special methods, are used to gain information on the progress of the reaction. The methods adopted are continually being improved. In the case of isothermal annealing of martensite, such structure studies have been supplemented by work in which the progress of the reaction in its early stages is followed by dilatometric registration. For this, a special instrument and appropriate auxiliary apparatus for rapid adjustment to the desired constant temperature have been developed. So much for the experimental side. Parallel to these experiments, the quantitative description of the effects recorded, in other words, a description by mathematical theory, based on the concepts of solid state physics, is being undertaken. In the course of this theoretical work, several earlier observations, which so far have resisted attempts at a rational interpretation, have been subjected to a fresh theoretical attack and have, indeed, received a natural explanation.

The investigations in this section are not entirely limited to solid state reactions. Considerable work is devoted to solidification structures. Graphite formation in cast iron is one topic here; another is the development of voids and the nature of porosity in copper-base castings.

In speaking of structures, the atomic arrangements in the crystal grains which build up the metal products is also of importance. A long-term research, aimed at exposing the atomic arrangements in certain aluminium-iron-silicon alloys is now in progress.

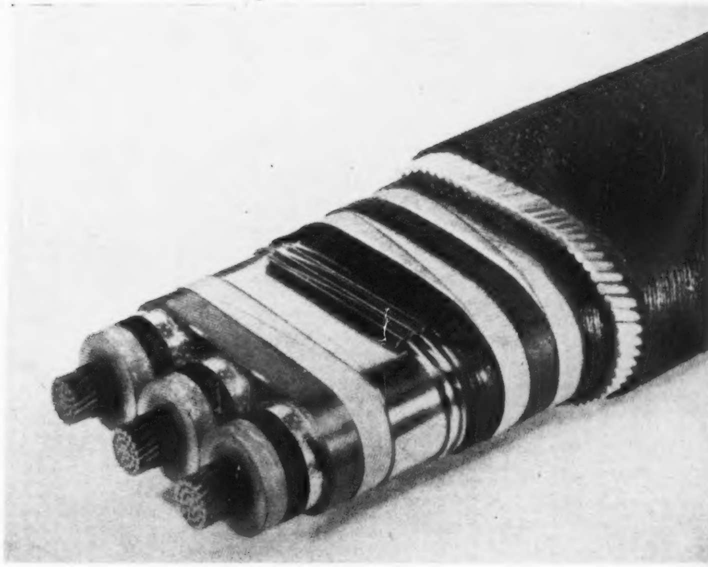
In this brief survey, only a pick of the projects undertaken has been presented. A complete list would be considerably longer. Such a list would none the less show that several important fields of metal research have been left untouched at the Institute. Of these omissions, of which we are indeed aware, some are particularly regrettable. The truth is that the economic resources available are meagre, and in the first place this puts a severe limit to the Institute's personnel. With a total staff of 30, of whom 8 are university graduates, it has been deemed essential to concentrate efforts as much as possible on a few important problems, for which our resources, especially the experience possessed by the responsible research men, would seem promising.

Obvious gaps in the Institute's research front have prompted the establishment of special research groups among the industrial firms most concerned. These groups have been offered laboratory space at the Institute, where they conduct research with personnel of their own, research at their own expense. Such groups are now active in powder metallurgy, and in research on the mechanical behaviour of alloys at high temperature. A somewhat similar situation exists for the more applied work on high temperature ceramics, and for the foundry laboratory of the Swedish Mechanical Industries' Association. These, too, have made the Metallografiska Institutet their home.

Works Visit

N.K.T. Cable Works and Rolling Mills

By BØRGE LUNN
M.Sc., Dr.techn., F.I.M.
(*Technical Director, N.K.T.*)



Flat-type submarine cable

FOUNDED in 1898, N.K.T. (Aktieselskabet Nordiske Kabel- og Traadfabriker), now employs more than 4,000 people in its three plants in Copenhagen and one in the country. In 1951 a new factory was erected west of Copenhagen, in which about 1,000 people are employed.

Copper wire, supplied to the cable works as hot-rolled rod, is pickled in sulphuric acid. The copper-rich acid is circulated through an electrolytic plant which removes the copper and returns the enriched acid to the pickling bath. Rinsing water, after removal of copper content, is discharged into a neighbouring stream. Annealing is carried out either in continuous furnaces with protective atmosphere produced by partial burning of liquid gas or by batch annealing in vacuum furnaces which, with sufficient high vacuum, produces a clean anneal with the minimum possibility of hydrogen embrittlement. The wire is stranded to bare cables on a variety of stranding machines. Aluminium wire is drawn and stranded to steel-reinforced aluminium cables in a separate department.

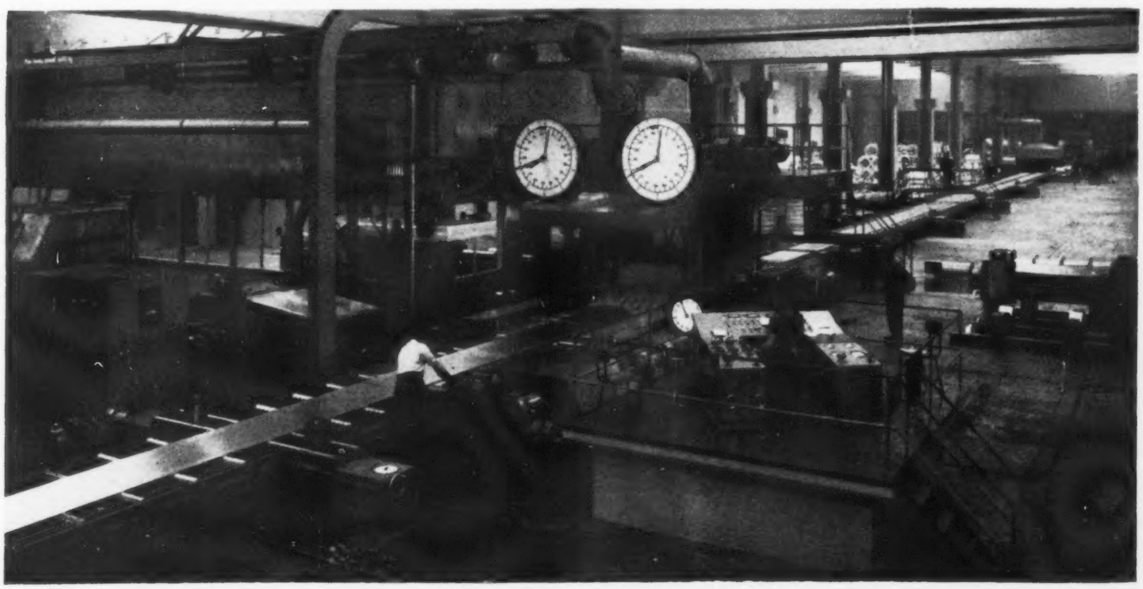
In the power cable works, conductors are stranded and insulated with paper for impregnation with oil and dried in large vacuum vessels. The lead sheath is extruded from continuous screw extruders and later protected with covering and armouring before coiling on the cable drums. The final product is laboratory tested, and close to the cable works a new high-voltage testing and development laboratory is being erected for research on new high-voltage power cables. A special development by the cable works is the Møllerhøj flat oil-filled pressure cable which, owing to its elastic girdle, functions without special pressure vessels for the expanding oil.

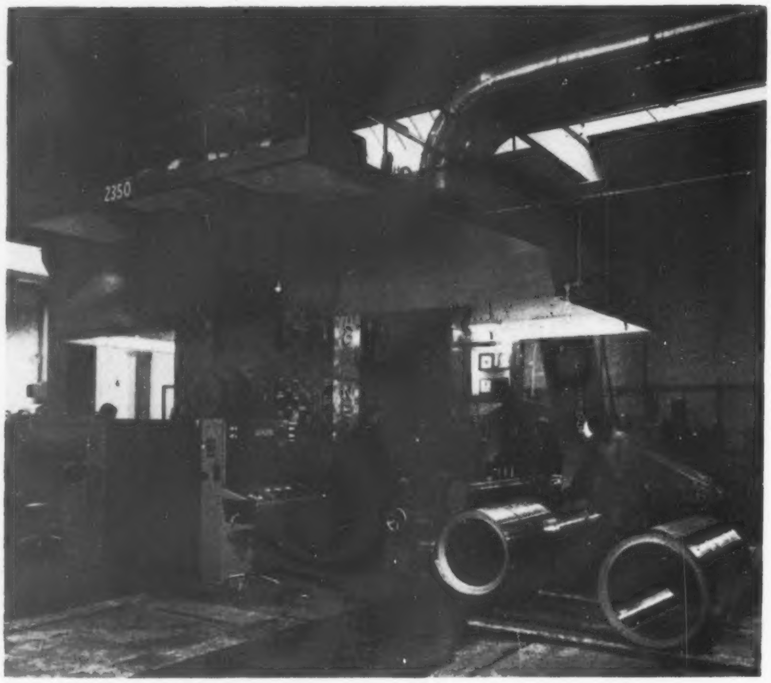
Adjacent to the power cable department is a department for the production of plastics-insulated wires. A new building for this production is under construction.

The rolling mills consist of three buildings: the brassfoundry, the brass mill and the aluminium mill.

Melting in the brassfoundry is carried out in low frequency induction furnaces for brass and higher copper alloys, some oil-fired crucible furnaces being available for other alloys. The metal is cast in copper-faced water-cooled moulds and scalped on a milling

Achenbach 2-high reversing mill for hot rolling both aluminium and copper alloys





Entry side of the 4-high cold mill

machine before hot rolling. In the brass mill, the hot rolled slabs are scalped on a pendulum milling machine and transferred to the 4-high mill by means of a crane equipped with suction pads.

The 4-high mill of American manufacture, is used for both roughing and finishing. To produce large coils, welding is used to some extent. Annealing is carried out both in batch furnaces and continuous furnaces, some with protective atmosphere for bright annealing of copper and to facilitate later pickling of the brasses.

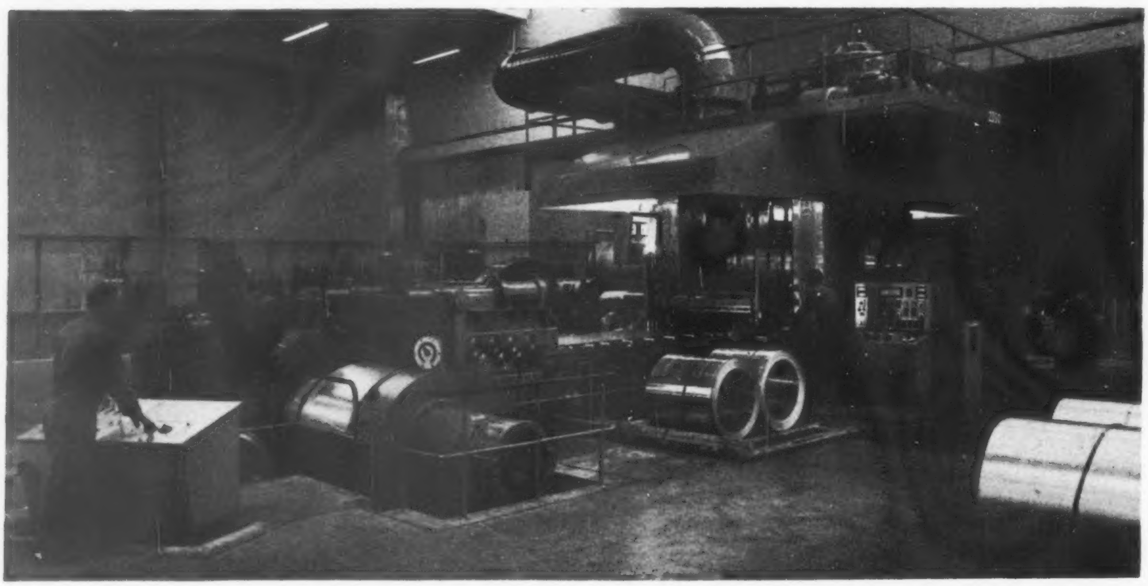
The aluminium mill covers an area of 13,000 m^2 and contains scalping machines for the aluminium rolling cakes, which are supplied from Norwegian reduction plants. The cakes, with a minimum weight of 500 kg., are heated in an oil-fired pusher furnace, and delivered by an overhead crane to a 2-high reversing mill constructed by Achenbach, Germany. This mill is unique as it is a reversing 2-high mill equipped with A.C. motors (2×720 kVA) running on the 10 kV grid. The run-out tables are of a light design, with inclined loose rollers on the table and vertical driven rollers working on the edge of the slab. Since the mill is also designed to roll copper and brass, it is equipped with special rolls which can be changed easily, and with two lubricating systems, one for light alloys and one for copper alloys.

The change from one type of alloy to another takes a few hours, including complete cleaning of all surfaces in contact with the metal, and a complete check on cleanliness is obtained by analysing the deposits in the filter pads of the lubrication system.

Copper and brass cakes are heated in an oil-fired walking beam furnace, and the rolled slabs are received at the one end of the run-out table by a special movable receiving platform for transport to the brass mill.

At the other end of the run-out table, hot-rolled aluminium is coiled on a hot coiler under back tension from a bridle to prevent any deterioration of the hot-rolled surface. After cooling, the hot-rolled aluminium coils are cold rolled in a 4-high reversing mill. This is a conventional reversing 4-high mill with D.C. drive from a Ward Leonard generator and provided with an elaborate cooling system; thickness measurement is made radiologically using strontium 90. The cold rolled coils, which can be produced up to 1,250 mm. width, are annealed in electric furnaces with air circulation. The material is processed further on smaller 2-high mills, or slit to strip, cut to sheets or formed to corrugated sheets. Circles and special sheets are annealed in a flash annealing furnace. Parallel to the aluminium rolling mill, a foil mill is under construction; this mill will contain a modern 4-high dual purpose mill for the production of foil in 4 ft. widths. It is expected to be in operation in the Spring of 1960.

Delivery side of the 4-high cold mill for aluminium



Works Visit

Andersen and Bruun's Fabriker A/S Copenhagen

By JØRGEN SPAGER, M.Sc.

(Managing Director, Andersen and Bruun A/S)

Some of the wide variety of sizes and shapes of collapsible tubes produced by Andersen and Bruun's Fabriker A/S

SINCE the war, Danish industry has expanded rapidly, and a prominent part in this expansion has been played by Andersen and Bruun's Fabriker A/S. Founded in 1915 by Otto Johannes Bruun, the present chairman, as a factory for the manufacture of collapsible tubes, the company has during the past years taken up the production of many other products, especially for packaging, as well as machinery for these purposes, and is to-day the largest in Scandinavia within this field. The company is carrying out extensive research work, and is thus taking an active part in the development of one of to-day's most promising industries.

The main activities of the company are the manufacture of:

(1) Collapsible tubes of aluminium and soft metal.

(2) Bottle capsules of aluminium and lead.

(3) Aluminium foil containers and dishes.

(4) Conversion of aluminium foil.

(5) Machinery for making collapsible tubes, capsules, foil containers and dishes, and machines for foil conversion.

In Denmark, the annual consumption of collapsible tubes is estimated at 40-45 million, aluminium tubes now accounting for almost 60 per cent of the total consumption. The major part thereof is made by Andersen and Bruun, who were pioneers in this field in Denmark. Collapsible tubes are made either on fully automatic production lines used for long runs, or on semi-automatic lines that are most suitable for the smaller orders. Most of the machines used by Andersen and Bruun are of their own construction. The firm are also manufacturers and exporters of tube-making machinery.

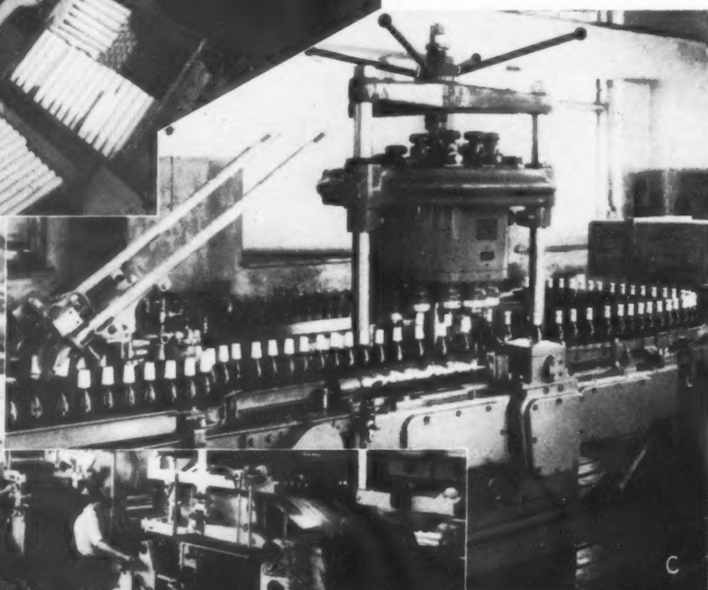
In 1918, an old-established lead capsule factory was taken over and this now supplies practically the entire Danish consumption of lead capsules, the market being restricted to the wine and spirit trades.

Around 1930, O. J. Bruun invented

Part of the collapsible tube factory

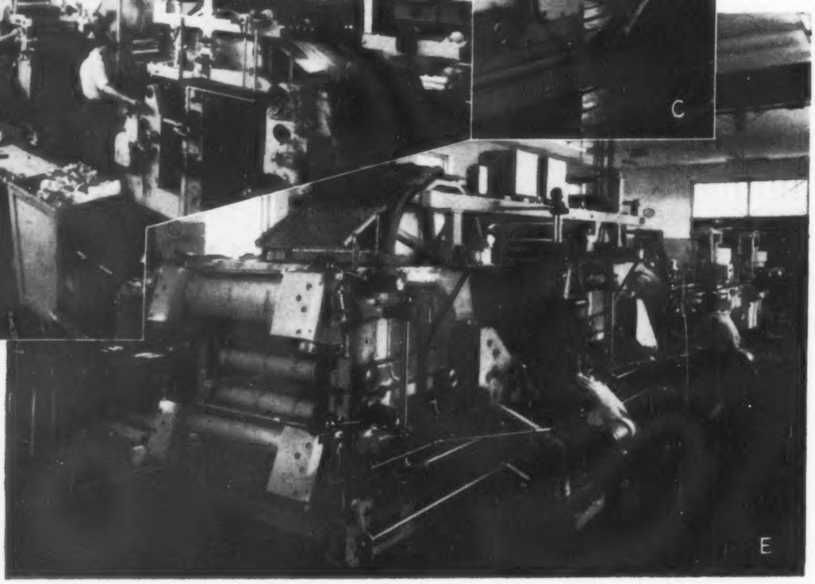
A—Production of pleated aluminium bottle capsules

B—Capsule decoration



C—A Super Multiplex fully-automatic bottle capping machine

D—Some of the machines in the foil factory



E—An "Anilex" four colour flexograph printing machine under construction at the "Abmaco" machine works

Aluminium dishes are used in the packaging of a wide variety of foods

The Alu-Cup, an airtight container

the pleated aluminium bottle capsule. Due to the cheapness of these new capsules, it was possible to find new markets for the "Alu-capsules," for instance, beer, and to-day annual world consumption is more than 2,000 million, about 25 factories producing them under licence on machines supplied by the works in Copenhagen. They are produced on fully-automatic presses at the rate of more than 70 per minute, and the decoration (for instance, coloured side and top) is also done fully automatically.

A wide range of capsuling machines has also been developed to meet different requirements, ranging from small hand-operated machines to the fully-automatic machines "Multiplex" and "Super-Multiplex" for dealing with up to 24,000 bottles/hr. More than 100 bottling plants all over the world are using these automatic units.

During the last few years, a considerable change has taken place in retail distribution in Denmark. The trend is now towards "super-markets" and other shops based on self-service. This method of distribution makes great demands on the packing of the goods, and Andersen and Bruun have developed a wide range of new packings for this purpose.

An interesting feature is the "Alu-Cup," an airtight container with great eye appeal, which has become very popular for the packing of a great variety of products, foremost of all processed cheese, and has contributed largely to the increase of processed cheese exports. The manufacture of these containers is fully automatic and carried out on the same principle as the bottle capsules. By using the patented "Alu-Cup" and a special sealing machine, also made by the company, an airtight seal can be effected.

Aluminium foil dishes are manufactured in many sizes, with and without lids made from cardboard or aluminium. These dishes, the so-called "Alu-Bak," have found an extensive market for pastry, ready-to-serve dishes, lard, liver paste, and so on. A simple hand apparatus is supplied to small retailers for closing the "Alu-Bak," food factories using automatic closing units.

The raw materials used in the foil conversion factory are mainly aluminium foil and paper, to which may be added various transparent foils. The works comprise a large printing section for both rotogravure and flexograph (aniline) printing. One of the main articles produced is "Sani-Foil" (aluminium foil laminated with parchment), which is used for wrapping butter for export. Wash-off-able foil labels, an Andersen and Bruun speciality, have found ready acceptance in the brewing industry. Many other packs are produced, for instance for biscuits, margarine, ice cream, chocolate, confectionery, rye bread, soup powder, etc.

A wide variety of machinery and equipment for "Alu-Capsules," foil containers, collapsible tubes and foil conversion, has been designed and developed by the company, which exports single machines and complete factories.

Technical University of Copenhagen

By Prof. E. KNUTH-WINTERFELDT, Dr.techn.

BESIDES the primary duty of the Laboratory of Metallurgy of providing lectures and practical courses in metallurgy, research is carried out in different physical metallurgical fields; some consultative work is also done for industry.

All students in the chemical, mechanical and electrical engineering departments attend lectures in metallurgy, the laboratory courses being open to those students who specialize in metallurgy, normally numbering about 6-12 a year. Both in the lectures and in the laboratory courses the chief weight is laid on physical metallurgy, because the demand for process metallurgists in Denmark is negligible. Teaching of mechanical technology is taken care of by another department at the University, the Laboratory of Mechanical Technology.

Experimental and development work have been done for several years in order to improve the methods of preparation for specimens for microscopical examination. As a result, special apparatus for electrolytic polishing and for wet grinding has been developed in collaboration with Danish firms. The nature of chemical and electrolytic polishing processes has also been investigated.

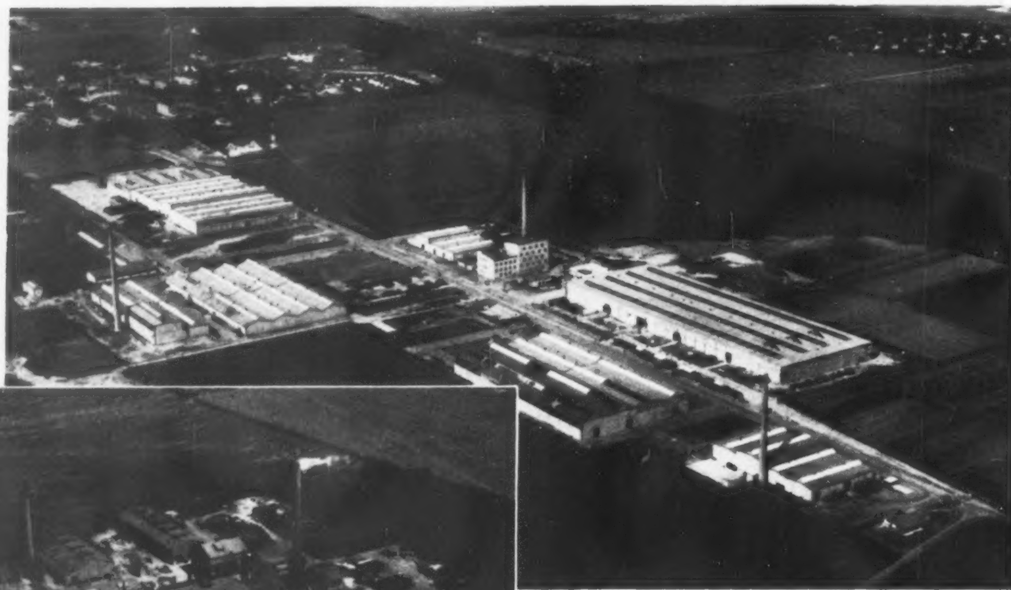
An experimental research programme on the nature of friction and wear processes under different conditions has been carried out for several years; the work is not finished, but the preliminary results seem promising.

The quench-ageing process in supersaturated, low carbon ferrite is being investigated by means of the electron-microscope, by measurement of internal friction and by analysis of isolated carbides.

In the corrosion field, experiments are being carried out to evaluate different zinc alloys for use as protective anodes in sea water.

The laboratory answers about one hundred problems from industry every year, mostly concerning failures after incorrect heat-treatment, fatigue or corrosion.

The present equipment permits ordinary scientific investigations to be carried out in most fields of physical metallurgy, including electron-microscopy and diffraction, excluding X-ray studies.



Top right: The works of Nordiske Kabel-og Traadfabriker

Lower left: Smelting and refining works of Paul Bergsoe and Son

Non-Ferrous Industries in Denmark

By BØRGE LUNN
M.Sc., Dr.techn., F.I.M.

ALTHOUGH there are no ore deposits in Denmark, non-ferrous metals have been worked since the bronze age, from about 1500 B.C. During the 400 years until 1814, when Norway was united with Denmark, Norwegian copper was being worked to sheets for the roofing of churches and castles in the two countries. Many of the green copper roofs in Copenhagen date back to that time.

The industries of to-day are concentrated on two companies, one which is based on the smelting and refining of non-ferrous scrap, and one which produces semi-manufactured goods from imported metals. Being a small country, with a population of only 4½ million, and with industries based on agriculture, shipping and materials for cement, the domestic market is rather limited.

The smelting and refining works of Paul Bergsoe and Son were founded by Paul Bergsoe in 1902. It was originally a plant for detinning of tin plate scrap from the canning industry, but was later developed into an industry dealing with non-ferrous and precious metals. The company specializes in solders, printing metals, Babbitts and special high grade foundry ingots and the export of these materials is a major part of present-day activities. Originally, the manufacture was dependent on domestic scrap and residues, to-day the company imports ores and concentrates from all over the world to its furnaces. The processes of the company, and the idea of control of the products and the distribution of technical knowledge to the users of the metals, are based on the original work of Dr. Paul Bergsoe who still, at the age of 87, is well known to the Danish public for his ability to explain natural sciences in a popular way over the broadcasting system.

The production of semi-manufactured goods is undertaken by N.K.T. ("Aktieselskabet Nordiske Kabel-og Traadfabriker": viz. Northern Cable and Wire Works Ltd.), which was founded as a private company in 1891 for the manufacture of electric wire and in 1898 transformed into a limited company making cables, copper and iron wire and iron wire products. This company acquired, in 1907, the old metal rolling mill in Frederiksværk, a mill which dates back to before the year 1800 and was based upon the power from a small stream which to-day is the fresh water supply for the new large steel mill in the same area. The rolling mill was moved to Copenhagen in 1909 and has since developed, producing semi-manufactures for the domestic market. The works produce plate, sheet, strip and foil of copper and copper alloys, aluminium and lead, extrusions, wire, pipe and tube and also conversion of aluminium foil. The production rose with the increasing population and increasing industrialization, and in 1951 new works were erected in an area west of Copenhagen; these include a modern brass foundry, a brass strip rolling mill and an aluminium rolling mill.

It requires some skill to produce the whole range of non-ferrous semi-manufactures at competitive prices and qualities with only a comparatively small market. The co-operative spirit of the Danish industries has been valuable for this development.

Beside the two mentioned companies a few smaller companies exist which produce ingots of aluminium and copper-base alloys from scrap, and among the metal consuming industries are the many metal foundries, the electrical, the ship building and the refrigeration industries all of which contribute to the growing industrial activity.

Industrial News

Home and Overseas

Institute of Metals

A one-day Symposium on "The Application of Thin-Film Techniques to the Electron-Microscopic Examination of Metals", arranged by the **Metal Physics Committee** of The Institute of Metals, will be held on Thursday, November 12, 1959, at the Royal Institution, 21 Albemarle Street, London, W.1, beginning at 9.30 a.m. Visitors will be welcome and tickets are not required.

The following eight Papers will be presented and discussed: "Techniques for the Direct Examination of Metals by Transmission in the Electron Microscope", by P. M. Kelly and J. Nutting (University of Cambridge). "An Outline of the Theory of Diffraction Contrast Observed at Dislocations and Other Defects in Thin Crystals Examined by Transmission Electron Microscopy", by M. J. Whelan (Cavendish Laboratory, Cambridge). "Observations of Dislocations in Metals by Transmission Electron Microscopy", by P. B. Hirsch (Cavendish Laboratory, Cambridge). "The Observation of Anti-Phase Boundaries during the Transition from CuAu I to CuAu II", by D. W. Pashley and A. E. B. Presland (Tube Investments Research Laboratories, Cambridge). "Electron - Microscopic Studies of Precipitation in Aluminium Alloys", by R. B. Nicholson, G. Thomas and J. Nutting (University of Cambridge). "Electron-Microscopic Observations on the Recrystallization of Nickel", by W. Bollmann (Battelle Memorial Institute, Geneva). "The Martensite Transformation in Thin Foils of Iron Alloys", by W. Pitsch (Max-Planck-Institut für Eisenforschung, Düsseldorf). "The Growth, Structure and Mechanical Properties of Evaporated Metal Films", by G. A. Bassett and D. W. Pashley (Tube Investments Research Laboratories, Cambridge).

Our Biggest Export

Speaking at a Malvern conference last week, Mr. F. J. Fielding, managing director of the Heenan group of companies, said, in the course of his address, that engineering was "the biggest export we have, and we live by it. It is the industry which contains the highest brain content and demands the greatest monetary return".

"History has shown", he continued, "that we in this country have been able to provide this brain content. Our future demands that we should continue to do so in a world of competition increasing at an enormous pace."

The theme of the conference, organized by the Herefordshire and South Worcestershire Committee of the Engineering and Allied Employers' West of England Association, was "Education and the Engineering Industry".

A Birmingham Function

Briefly describing the ancient and traditional glories of the City of London, Alderman E. N. Hiley, secretary of the National Brassfounders' Association, addressed the members of **The Non-Ferrous Club** at its monthly meeting at the Queens Hotel, Birmingham, on Wednesday of last week. Outlining some of the traditional Guildhall procedures, Mr. Hiley emphasized how valuable these traditions are, and how superbly they were maintained.

At this meeting a collection was taken on behalf of the Birmingham Federation of Boys' Clubs, the sum of £17 2s. 6d. being realized.

Welding Technology

A new prospectus of the School of Welding Technology has just been issued by the **Institute of Welding**. This prospectus gives details and syllabuses of courses being organized from November this year to March 1960 on a wide variety of welding topics.

Some of these courses are already almost fully booked, but full details and copies of the prospectus may be obtained on application to the offices of the Institute at 54 Princes Gate, London, S.W.7.

Thailand Tin Venture

News from Bangkok is that the Director-General of the Thailand Mines Department has announced that a joint Thai-foreign company, known as the Oawa Kham Tin Company, is attempting to mine tin ore from the sea off Puket Island in southern Thailand. It is reported that the capital of the company is 1,980,000 Malayan dollars. The Government has 35 per cent interest in the company, private Thai citizens 12 per cent, while the remaining shares are held by British and Malayans.

Trade with Sweden

New offices in Stockholm have just been opened by **Simmonds Aerocessories AB**, a member of the Firth Cleveland group. The new offices are at Alvajo, on the outskirts of Stockholm, and occupy the first floor of a newly-erected modern building.

Mond Nickel Exhibition

After a successful week in Birmingham, the **Mond Nickel Company Limited** is staging their exhibition at Marlands Hall, Southampton, from October 27 to 30 next. It will be opened by Rear-Admiral W. F. B. Lane, D.S.C., M.I.Mech.E., Director of Marine Engineering, Admiralty. Over 12,000 designers and technicians have been invited to visit the exhibition, which features the properties of nickel, nickel-containing materials and the platinum metals, and to discuss the latest developments in the nickel industry with members of the company's development and research department.

Welding Design

In conjunction with the **Aluminium Development Association,** the **Institute of Welding** has arranged a course of instruction on welding design and construction in aluminium and its alloys. The course will include welding methods, material selection, metallurgical considerations, engineering features, inspection and testing, typical applications, and recent developments. Lectures will be combined with discussions, film shows and visits to works and laboratories.

The course will be held at the headquarters of the Institute from November 9 to 13, 1959, inclusive, and the fee, which includes transport to works visits, is 16 guineas for non-members and 13½ guineas for individual members and staffs of industrial corporate members only. Students are expected to have received full engineering or metallurgical training. The number that can be accepted is limited, and applications should be made without delay to the Institute of Welding, 54 Princes Gate, London, S.W.7.

Anti-Vibration Nut

A new all-metal potentiometer anti-vibration nut has just been introduced by **Simmonds Aerocessories Ltd.** This new nut is made of aluminium alloy B.S.S.1476 H.E.10, with internal threads of ⅜ in. by 32 t.p.i. and external threads ⅝ in. by 28 t.p.i. It has a spring steel, cadmium plated locking insert, which gives a highly consistent performance.

Priced at 55s. net per 100, these nuts can be supplied with identification washers made of light alloy 22 S.W.G., with anodized finish, in six different colours, at 3s. 9d. net per 100.

Training for Industry

In his presidential address to the **Institution of Electrical Engineers** last week, in London, Sir Willis Jackson made an appeal to industry to collaborate with the educational authorities in the matter of teaching technological subjects at all levels. He said that there were outstanding weaknesses in our educational system because of a tendency to look upon the schools, technical colleges, universities and industry as completely separate compartments.

It was unrealistic, said Sir Willis, to suppose that the teaching of technology at its highest level could be carried wholly or largely by men who occupied full-time teaching positions, unless they returned to industry at intervals. He regretted that separation of the D.S.I.R. establishments from the domain of technological teaching, and the lack of a recognized link between them and the universities for scientific and technological research.

Sir Willis felt that the shortage of industrial training facilities had become the Achilles heel of our national plans for the further development of technological and technical education. The smaller and more specialized firms, he continued, should collaborate in the organization of group training schemes in which their limited individual resources were properly co-ordinated. He said he was increasingly concerned with the high degree of subdivision which characterized the country's industrial structure. This produced among the larger organizations a considerable multiplication of research, development, and design effort directed to the same or substantially the same, technical objectives, and the possibility that not one of these concerns had the resources either of manpower or finance to launch a really major attack on a new field.

French Import Liberalization

Recent news from Paris indicates that quantitative import restrictions in the French community for purchases in west European countries, the United States and Canada and other countries have been removed for a wide range of goods. The trade liberalization, issued in the Journal Officiel, will apply to the Republics of the Ivory Coast, Dahomey, Upper Volta, Mauritania, Niger, Senegal and Sudan. It

is in addition to the list of import liberations in force since June 14, 1957, for French West Africa.

There are three new lists—one for O.E.E.C. countries, another for the United States and Canada, and a third for the remaining countries. The list for O.E.E.C. countries includes edible oils, some chemicals, solvents, iron and steel. The list for the United States and Canada includes oils and waxes, special earth, some minerals, gypsum, some chemicals, aluminium and lead.

The list for countries other than the United States, Canada and O.E.E.C. countries is almost identical to that issued for dollar countries.

Theft of Metal

It is learned from the National Association of Non-Ferrous Scrap Metal Merchants that the following was stolen during the week end 3/4 October, from Andrews Metals Ltd.: Approximately 18 cwt. of clean burnt H.C. copper tape in cylindrical bales approximately 12-18 in. in length by 6 in. diameter.

Any firm able to give assistance in this matter should contact Andrews Metals Ltd., of Stratford Road, Shirley, Solihull, Warwickshire. Telephone Shirley 1286.

B.O.T. New Office

On Wednesday last the Midland Regional Office of the Board of Trade moved to Somerset House, Temple Street, Birmingham 2. It is understood that the Midland Regional Board for Industry has also moved to this same address.

A Works Visit

On Tuesday of last week, Mr. E. G. Gardner, pattern shop manager, of **Hadfields Limited,** presented a Paper entitled "Epoxy Resin in Patternmaking" to over 45 members of the National Trades Technical Societies who were visiting the East Hecla works of the company.

During his address, Mr. Gardner referred to recent developments in patternmaking and the benefits gained by the use of epoxy resin to industry. A practical demonstration was given by Mr. Cedric Platts on "How It Should be Done", and afterwards the meeting was open to members of the society, who proceeded to ask many technical questions on the skills and applications of patternmaking.

The members of the society who attended were representative of the many pattern shops and foundries in the Sheffield area.

At The Building Exhibition

On the stand to be occupied by the **Northern Aluminium Company Ltd.** at the forthcoming Building Exhibition in London, the emphasis will be on aluminium building sheet in a wide range of profiles designed for roofing and siding of many types of building.

Foremost will be "Snaprib", an unusually attractive system, combining the traditional advantages of aluminium building sheet with a method of concealed fixing that enhances appearance and ensures perfect weathertightness. It can be supplied in any length likely to be required, avoiding end-laps in low-pitched roofs. Snaprib will be displayed in the several finishes in which it is obtainable, and in photographs illustrating its growing popularity for domestic housing, schools and the like.

Other profiles to be shown will include Noral "deep trough industrial" sheet, which this company has recently introduced for long spans, also thin-gauge shallow-troughed sheet now being used for internal lining, and the "Standard Industrial" and "Mansard" sheets. A sandwich-wall system is also to be shown which incorporates these last two profiles with an inter-layer of glass fibre, while there will be a demonstration of stud welding, the method used to attach the sheets to the purlins.

A Birmingham Function

Election night added variety and a touch of excitement to the annual ball of the **Royal Metal Trades Pension and Benevolent Society,** which was held on Thursday of last week at the Grand Hotel, Birmingham. In spite of the General Election having fallen on the date prearranged for this event, a satisfactory attendance was recorded, some 370 guests being present, among whom were Mr. E. Jackson, President of the National Federation of Ironmongers, and Mr. W. M. McDonald, President of the National Brassfoundry Association.

Post-Graduate Courses in Metallurgy

Two post-graduate courses have been arranged at the Metallurgy Department of the College of Advanced Technology, Birmingham. One is entitled "Recent Advances in Metallographical Techniques" and the other "Directionality in Metallic and Non-Metallic Materials". Both courses are in the form of nine weekly evening lectures, each by an authority in his particular field.

The first-mentioned course commences on Thursday, October 22, and continues thereafter on successive Tuesdays, while the second will be held on Wednesday evenings from October 21 onwards. It is considered that these courses will be of particular value to scientific workers in industry, in enabling them to keep abreast of modern developments, and the fullest support of local industry is anticipated. Full particulars are obtainable from the Department of Metallurgy, College of Advanced Technology, Birmingham, 4.

David Brown Tractors in India

It is reported that the Government of India has approved a proposal whereby **David Brown** tractors are to be manufactured in India. It is understood that under this proposal the company expects to produce some 1,250 tractors annually in that country.

Malaya and Tin Agreement

According to reports from Kuala Lumpur, Malaya will seek "certain changes" in the International Tin Agreement when it comes up for review next June. The source declined to elaborate on what changes Malaya would seek, saying "we will try and have loopholes tightened up in the light of experience". The Federation (of Malaya) Tin Advisory Council met this week and decided that Malaya should send representatives to the I.T.C.'s next meeting in December.

Japanese Rolled Aluminium

Output of rolled aluminium products in Japan during August this year amounted to 8,000 metric tons compared with the post-war record of 8,157 tons in July last, according to the Japan Rolled Light Metals Association. The Association said that the strong demand for rolled aluminium products was expected to continue for months to come from the household electric appliances, motor cars and house construction industries.

August export contracts for rolled aluminium products fell slightly to 708·9 metric tons from the July total of 717·6 tons, while exports shipments in August rose to 622·6 metric tons from 580·3 tons.

Tin Research

The latest issue of *Tin and Its Uses* describes several new projects involving tin. Tin has always been considered harmful in cast iron, but recent careful investigations show that, properly controlled, it suppresses ferrite, and promotes the formation of the pearlite constituent without tending to cause massive cementite. This may lead to better wear-resistance in cast iron, coupled with good machineability.

A new flux medium, polyethylene glycol, reduces the bad spattering effects which cause the corrosion encountered with "killed spirit" (zinc chloride). The new fluxes spread much better and more uniformly and help solder to penetrate further into joints.

Wood-destroying fungi were unable to attack specimens of wood which had been impregnated with certain organotin compounds. Details of trials carried out at Delft, Holland, indicate that one of these compounds is particularly promising as a preservative.

1960 is the 150th anniversary of the invention of tinned foods and plans for celebrating the event are being prepared in many countries. In this issue of *Tin and Its Uses*, a synopsis of the plans so far announced indicates that England and the United States both regard the occasion as being of the highest importance.

U.K. Metal Stocks

Stocks of refined tin in London Metal Exchange official warehouses at the end of last week fell by 141 tons to 8,197 tons, comprising London 4,659, Liverpool 3,378 and Hull 160 tons.

Copper stocks fell by 1,516 tons to 11,547 tons, distributed as follows: London 2,497, Liverpool 6,100, Birmingham 225, and Manchester 2,725 tons.

British Exhibition in New York

Preliminary information is given regarding the British Exhibition which is to take place in New York from June 10 to 26 next year, and which has been organized by the **Federation of British Industries.** This exhibition will be held at the Coliseum Exhibition Building in the heart of New York City, and will occupy all four floors. It will be nearly twice as large as the recent U.S.S.R. exhibition in the same building.

All phases of British industry will be included, and among individual exhibits will be those provided by the British Government, in which entirely novel display techniques will be used to show the new as well as the old Britain, and some of our latest advances in science, technology and engineering.

The third floor of the exhibition will be devoted to engineering and industrial plant and materials. Heavy and light engineering products will be shown, and other sections will include electrical, mechanical and chemical engineering, machinery and equipment for all industrial processes, instrumentation, electronics and automation, etc.

Full particulars of this exhibition, space charges, shell stands, etc., may be

obtained from British Overseas Fairs Ltd., 21 Tothill Street, London, S.W.1, who are planning the exhibition on behalf of the F.B.I.

Metal Finishing

A new addition to the rapidly growing range of metal finishing interests held by **Albright and Wilson (Mfg.) Ltd.** is a duplex plating process that should be of considerable value to the automobile and allied industries. Last year the company introduced the Plusbrite process, which rapidly established itself as a bright nickel plating process that gave a fully bright deposit with better physical properties of plate than had hitherto been available.

The new process is a logical development of the original Plusbrite process, and is designed to give maximum corrosion resistance, together with a fully-bright plate, for such applications as motor car trim and similar automobile accessories. A new additive is used, Plusbrite S.F. PB-SF is a sulphur-free addition agent which, when added to the plating bath, produces an electrolyte giving a semi-bright deposit of high ductility and low internal tensile stress with excellent levelling properties. The deposit has a columnar structure. The standard Plusbrite solution is then used to produce a fully bright finish. As the second deposit is lamellar in structure, a very high standard of corrosion resistance is attained by the duplex process. A similar duplex process has been marketed in the United States since the early months of this year.

Plusbrite S.F. is stated to be very stable. Operating costs can be kept to a minimum during processing, as there is no loss by filtration through carbon.

Spray Booths

Over the last six years, intensive development work has been done by **Alfred Bullows and Sons Ltd.** to produce a new, more satisfactory, and cheaper water wash spray booth. The result of this is the "Nopump" booth, which has now been on the market since the beginning of 1959. The fundamental change is that, as its name implies, the "Nopump" booth has no water circulating pump.

In the conventional system, there is a centrifugal water circulating pump with its attendant piping, nozzles and filters, all prone to trouble and excessive maintenance when handling water heavily contaminated with paint. In the "Nopump" both, a stream of air at very high velocity licks the surface of the water, entraining a large amount of water in the air. This air-water mixture, still travelling at very high velocity, is forced to make a number of carefully controlled changes of direction, during which the heavier paint particles are thrown, by centrifugal force, into the water stream. The water is then separated from the air by a number of eliminator plates, the clean, exhaust air being taken to atmosphere and the water returning to the tank.

As there are no filters, the degree of contamination of the water has little or no effect on the operation of the booth. If the collected paint is encouraged to sink, the booth will go on running until the water tank is virtually full of collected paint, which is in the form of silt.

There is said to be no sacrifice of washing efficiency, in fact the reverse: the exhaust air from a "Nopump" booth is outstandingly clean.

Men and Metals

New appointments have recently been made by British Insulated Callender's Cables Limited as follows: **Mr. F. V. Thompson,** F.C.I.S., A.A.C.C.A., has been appointed director of personnel, and has relinquished his position as secretary of the company. **Mr. J. P. Hourston,** B.Com., C.A., has been appointed secretary. **Mr. G. V. Tew** has been appointed assistant secretary.

A director and chief electrical engineer of Metropolitan-Vickers Electrical Company Limited, **Mr. C. H. Flurscheim,** B.A., M.I.E.E., has been co-opted to serve on the Council of the British Welding Research Association. He became chief electrical engineer of Metropolitan-Vickers in 1957 and a director in 1958.

Personnel director of Accles and Pollock Limited, **Mr. John Maslin** has been elected President of the Institute of Personnel Management. He will serve in that office for two years.

We are informed by Airtech Limited that **Mr. R. C. McCormick,** B.A., M.Sc., has joined the company as chief electronics engineer. After graduating with 1st Class Honours in experimental physics from Dublin University in 1949, Mr. McCormick was an assistant engineer in the Department of Posts and Telegraphs, Ireland. He later joined Mullard Research Laboratories, and prior to taking up his present position with Airtech, was with Ultra Electric Special Products Division as executive engineer.

Appointments recently announced by British Insulated Callender's Construction Company Limited include that of **Mr. R. Betley** as an executive director. Mr. Betley joined the company in 1919. The retirement of **Mr. C. H. Frankland,** M.I.E.E., from the board of the company is also announced. Mr. Frankland was appointed a member of the board in 1949.

Following the retirement of **Mr. H. F. G. Bicker** as manager of the Exeter branch of British Insulated Callender's Cables Limited, it is announced that **Mr. R. A. Turpin** has been appointed to fill that position. Mr. Turpin joined the company in 1949 as a representative at the Exeter branch.

It is learned from the Imperial Smelting Corporation Limited that **Mr. S. W. K. Morgan** has been appointed a director of the company.

Director and assistant director respectively of the International Tin Research Council, **Dr. E. S. Hedges** and **Mr. W. R. Lewis** are to make a three-week South American tour this month. This is the first occasion that officials of the Council have visited South America. Dr. Hedges will lecture in Spanish at universities in Brazil and Bolivia, and Mr. Lewis is to address leading tin consumers. They both left London last week-end for Lisbon to attend the annual conference there of the Comité International Permanent de la Conserve, before travelling to Brazil. Dr. Hedges is a member of the C.I.P.C. scientific committee, and Mr. Lewis is President of its committee on information and statistics.

Following the resignation of **Mr. P. J. Scratchley** from Union Carbide Limited, Alloys Division, it is understood that **Mr. R. Wilson,** divisional managing director, has temporarily assumed the responsibilities of sales manager for the Alloys Division.

Appointment of a new technical representative was recently announced by Armstrong Whitworth (Metal Industries) Limited. He is **Mr. Ian Robinson,** who has been appointed to cover the complete range of the company's products in the Sheffield area.

In place of Mr. Dawson, who has retired, **Mr. B. Williams** has been appointed resident technical sales representative at the Bristol office of Crofts (Engineers) Limited.

At the current month's meeting of the Institute of Physics, the following were elected Fellows of the Institute: **S. H. Ayliffe, B. J. Bok, J. C. Hawkes, J. W. Head, F. H. Hibberd, S. Kaufman, A. Langridge, J. L. Olsen, M. Pancholy, H. A. Vodden,** and **P. E. Wrist.** In addition, 45 new Associates were elected, 89 Graduates, 40 Students, and 2 subscribers.

Forthcoming Meetings

October 19—Institution of Production Engineers. North Midlands Region. Louis Room, St. James's Restaurant, St. James's Street, Derby. "What's New in Casting." A. Short. 7 p.m.

October 19—Institute of Metal Finishing. London Branch. Northampton Polytechnic, St. John Street, London, E.C.1. "High Temperature Anodizing." A. W. Brace and R. E. M. Polfreman. 6.15 p.m.

October 20—Institute of Metal Finishing. South West Branch. Saracens Head Hotel, Gloucester. "Anodizing Techniques in North America." A. W. Brace. 6.30 p.m.

October 21 — Institution of Plant Engineers. Kent Branch. The Kings Head Hotel, High Street, Rochester. "Metal Spraying and Ceramic Coatings." J. A. Sheppard. 7 p.m.

October 22—Institute of Metals. Sheffield Local Section. Applied Science Building of the University, St. George's Square, Sheffield. Symposium on Modern Analytical Techniques. (1)—"Modern Spectroscopic Techniques"; W. Ramsden. (2) "X-Ray Fluorescence"; K. W. Andrews. 2-5.30 p.m.

Metal Market News

THE excitement of the General Election, culminating on Thursday and Friday in excited trading on the Stock Exchange, was not reflected in Whittington Avenue where, apart from copper, the volume of business was rather disappointing and below average. Stability was, however, the keynote of the week and price changes were slight in spite of the disturbing elements of strikes in the United States, Chile and the Belgian Congo. Of these, two affected directly the production of copper, while the others were the three months' old steel strike and the Longshoremen's strike in the United States. It is certainly a matter for comment, that with such a disastrous background, in which loss of production shows up so prominently, copper does not stage an advance. In the United States alone the industry must have been deprived of about 100,000 short tons through the stoppage, and unless the Braden strike is settled promptly the loss of tonnage there will begin to mount up. L.M.E. stocks declined by 175 tons to 13,063 tons, but with a dock strike in progress in the United States it was felt that these stocks might remain at a fairly stable level. In regard to that the President has invoked the Taft-Hartley Act and, in consequence, there has been a speedy return to work. In Whittington Avenue the turnover was well on the way to 19,000 tons, an exceptionally large tonnage, but one which probably included a fair volume of carries. The close was £232, both positions, which meant a loss of £2 10s. 0d. in cash, but of only £1 10s. 0d. in three months. Values on the New York commodity market fluctuated from day to day and the two centres continued to influence each other from day to day.

It is certainly against all precedent that, with the El Teniente mine not producing, the standard market has failed to stage anything like an advance. Indeed, as already mentioned, last week saw a modest decline in both cash and forward copper. Shipments of Braden copper to Europe are normally heavy and it is, of course, a well known and highly estimated brand in metal circles in the United Kingdom. No news has come out of any *force majeure* declaration by the suppliers and it seems reasonable to suppose that pipe-line stocks are pretty comfortable. It is also likely that consumers, who, after all, have been hearing for some time past of the possibility of trouble at El Teniente, have done something about building up reserves. Certainly since the Braden stoppage was first announced there has not been any hint of panic buying in this country; nor, for that matter, has any indication come from the Continent that users were alarmed over recent developments in Chile.

There is, of course, a certain threat to Metal Exchange stocks implicit in the present situation, for of the 13,000 or so tons of standard copper reported as lying in official warehouses, by far the largest quantity is in the form of fine refined quality and could, of course, be taken up by consumers for consumption in their factories. Moreover, the backwardation had disappeared by Friday last, so that there is no premium for cash. Of the other metals, tin was unchanged in quiet trading at £794 10s. 0d. for cash and £795 three months. Lead gained 7s. 6d. for October and 5s. for January, to close at £70 12s. 6d. and £71 10s. 0d. for the respective months. Zinc was a little easier, losing 5s. for October at £87, and 7s. 6d. December, to close at £85 5s. 0d. In view of the prolonged steel strike in the United States it is felt that both tin and zinc keep up very well.

Birmingham

With Election tension relieved, there are good prospects of steady progress in the metal industries over the last quarter of the year. Fortunately, the oxygen strike was comparatively short-lived, though it caused serious interruptions in many works, not only in the motor trade but over a wide range of industries. A good demand exists for components for the car factories, and the improvement in industry generally has brought a welcome return of orders for commercial vehicles. The building trade is buying metal castings and pressings. Sales of domestic metal goods are on the increase. Export business is expanding slowly.

Steel is in good demand for the light engineering industries. Pressure for sheets for the motor trade is such that mills are working to full capacity on this class of steel. Re-rolling mills are benefiting by the activity in the market of small bars and sections. Output is larger than it has been for many months. Tube mills have booked more work in connection with oil pipe line construction. Makers of heavy plates have orders to keep them busy for some months ahead, and the market for heavy joists and sections is expanding slowly. Foundries are busy on castings for the engineering industries.

New York

Commodity Exchange copper was steady in quiet dealings over the week-end. In physical copper some business was reported at 35¼ cents per lb. by dealers. Traders said that the reports of difficulties at the Anaconda Raritan refinery may have induced some buying. Meanwhile, an Anaconda official indicated that the company was studying the effect of furnace shutdowns on commitments. If necessary, *force majeure* may be invoked on some deliveries, he indicated. The spot tin market was softer, reflecting the return of the dockers to piers, but steady in prompt and forward positions. Moderate consumer interest was noted in prompt tin. Lead and zinc were quiet.

Domestic consumption of purchased aluminium-base scrap in June 1959 totalled 42,278 tons, an increase of about 1,700 tons on the May total, according to the Bureau of Mines, U.S. Department of the Interior. Output of finished ingot totalled 30,772 tons, an increase of about 500 tons. Shipments of ingots from smelters' plants during June amounted to 31,109 tons, practically the same as in May.

Domestic mine shipments of manganese ore in June 1959 increased by 68 per cent over May to 26,000 short tons, according to the Bureau of Mines, United States Department of the Interior. Shipments of manganiferous and ferruginous ore totalled 136,000 short tons.

Imports of manganese ore containing 35 per cent or more manganese totalled 211,575 short tons, an increase of five per cent over May, as compiled by the Bureau of Census. Of the total imports, Brazil supplied 28 per cent, Ghana 25 per cent, India 20 per cent, Mexico 16 per cent and Portuguese Asia, the Union of South Africa, Angola, Chile, Belgian Congo, Cuba, Peru and Canada the remaining 11 per cent in decreasing order. Imports of ferromanganese totalled 25,864 short tons of ore equivalent, a decrease of four per cent from May. Total quantity of new material (domestic mine shipments plus imports of ore and alloy in terms of ore) increased by eight per cent over May to 263,439 short tons.

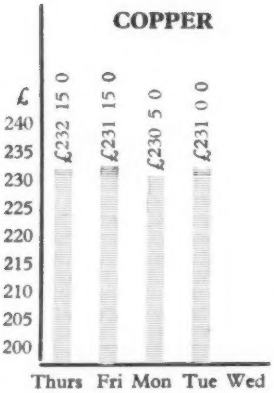
Sealed bids will be received at the Washington headquarters of the General Services Administration until 11 a.m. local time on November 27 to buy approximately 1,300 short tons of baddeleyite and 7,000 short tons of zircon sand. These zirconium ores were declared surplus to the needs of the U.S. national stockpile of strategic materials on March 12. The announcement by the G.S.A. fulfilled the requirements of the stockpile law that six months' notice of intent to sell from the national stockpile must be given to the trade. Sales would be made "where is—as is" f.o.b. carrier's conveyance. The minimum lot available for sale would be 120 short tons, G.S.A. said.

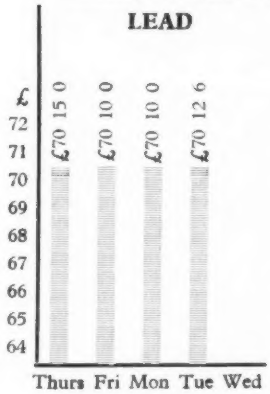
The three-man fact-finding panel appointed by President Eisenhower to enquire into the three months' old steel strike started public hearings last Monday. They have until to-day to report to the President, after which Mr. Eisenhower will ask the Attorney-General to seek a court injunction to send the men back to work for 80 days under the Taft-Hartley Act, while efforts for a settlement continue.

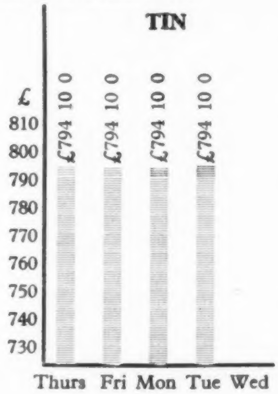
Non-Ferrous Metal Prices

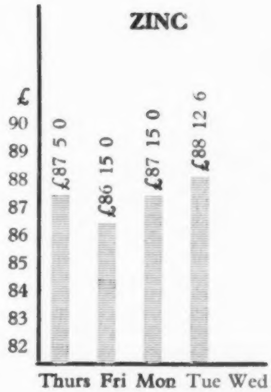
London Metal Exchange

Thursday 8 October to Tuesday 13 October 1959









Primary Metals

All prices quoted are those available at 2 p.m. 13/10/59

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	,,	197	0	0
Antimony Metal 99%	,,	190	0	0
Antimony Oxide	,,	180	0	0
Antimony Sulphide Lump	,,	190	0	0
Antimony Sulphide Black Powder	,,	205	0	0
Arsenic	,,	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	,,		9	0
Calcium	,,	2	0	0
Cerium 99%	,,	16	0	0
Chromium	,,		6	11
Cobalt	,,		14	0
Columbite .... per unit			—	
Copper H.C. Electro	ton	231	0	0
Fire Refined 99·70%	,,	230	0	0
Fire Refined 99·50%	,,	229	0	0

		£	s.	d.
Copper Sulphate	ton	74	10	0
Germanium	grm.		—	
Gold	oz.	12	4	11½
Indium	,,		10	0
Iridium	,,	24	0	0
Lanthanum	grm.		15	0
Lead English	ton	70	12	6
Magnesium Ingots	lb.		2	3
Notched Bar	,,		2	9½
Powder Grade 4	,,		6	1
Alloy Ingot, A8 or AZ91	,,		2	4
Manganese Metal	ton	245	0	0
Mercury	flask	71	10	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	,,		5	6
Osmium	oz.		nom.	
Osmiridium	,,		nom.	

		£	s.	d.
Palladium	oz.	7	5	0
Platinum	,,	28	10	0
Rhodium	,,	41	0	0
Ruthenium	,,	18	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	8
Tellurium	lb.		15	0
Tin	ton	794	10	0
***Zinc**				
Electrolytic	ton		—	
Min 99·99%	,,		—	
Virgin Min 98%	,,	87	6	10½
Dust 95/97%	,,	114	0	0
Dust 98/99%	,,	120	0	0
Granulated 99+%	,,	112	6	10½
Granulated 99·99+%	,,	128	11	3

**Duty and Carriage to customers' works for buyers' account.*

Foreign Quotations

Latest available quotations for non-ferrous metals with approximate sterling eqivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton		Canada c/lb ≏ £/ton		France fr/kg ≏ £/ton		Italy lire/kg ≏ £/ton		Switzerland fr/kg ≏ £/ton		United States c/lb ≏ £/ton	
Aluminium			22.50	185 17 6	224	168 0	375	221 5	2.50	212 10	26.80	214 10
Antimony 99.0					230	171 10	445	262 10			29.00	232 0
Cadmium					1,300	975 0					120.00	960 0
Copper												
Crude												
Wire bars 99.9							455	268 10				
Electrolytic	31.50	231 17 6	29.00	238 12 6	315	236 5 6			2.65	225 5	30.00	240 0
Lead			10.75	88 12 6	101	75 15	161	94 17 6	.87	73 17 6	13.00	104 0
Magnesium												
Nickel			70.00	578 5	900	675 0	1,200	708 0	7.50	637 10	74.00	592 0
Tin	111.00	817 2 6			1,124	843 0	1,500	885 0	9.70	824 12 6	103.25	826 0
Zinc												
Prime western			11.75	97 0 0								
High grade 99.95			12.35	102 0 0								
High grade 99.99			12.75	105 2 6								
Thermic					126.00	94 12 6						
Electrolytic					134.00	99 12 6	192	113 5	1.05	89 2 6	13.50	108 0

Non-Ferrous Metal Prices (continued)

Ingot Metals

All prices quoted are those available at 2 p.m. 13/10/59

Aluminium Alloy (Virgin)

		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	,,	202	0	0
B.S. 1490 L.M.7	,,	216	0	0
B.S. 1490 L.M.8	,,	203	0	0
B.S. 1490 L.M.9	,,	203	0	0
B.S. 1490 L.M.10	,,	221	0	0
B.S. 1490 L.M.11	,,	215	0	0
B.S. 1490 L.M.12	,,	223	0	0
B.S. 1490 L.M.13	,,	216	0	0
B.S. 1490 L.M.14	,,	224	0	0
B.S. 1490 L.M.15	,,	210	0	0
B.S. 1490 L.M.16	,,	206	0	0
B.S. 1490 L.M.18	,,	203	0	0
B.S. 1490 L.M.22	,,	210	0	0

Aluminium Alloys (Secondary)

		£	s.	d.
B.S. 1490 L.M.1	ton	152	0	0
B.S. 1490 L.M.2	,,	162	0	0
B.S. 1490 L.M.4	,,	178	0	0
B.S. 1490 L.M.6	,,	188	0	0

***Aluminium Bronze**

		£	s.	d.
BSS 1400 AB.1	ton	—		
BSS 1400 AB.2	,,	—		

***Brass**

		£	s.	d.
BSS 1400-B3 65/35	ton	—		
BSS 249	,,	—		
BSS 1400-B6 85/15	,,	—		

***Gunmetal**

		£	s.	d.
R.C.H. 3/4% ton	,,	—		
(85/5/5/5) LG2	,,	—		
(86/7/5/2) LG3	,,	—		
(88/10/2/1)	,,	—		
(88/10/2/½)	,,	—		

***Manganese Bronze**

		£	s.	d.
BSS 1400 HTB1	,,	—		
BSS 1400 HTB2	,,	—		
BSS 1400 HTB3	,,	—		

Nickel Silver

		£	s.	d.
Casting Quality 12%	,,	230	0	0
,, ,, 16%	,,	237	0	0
,, ,, 18%	,,	255	0	0

***Phosphor Bronze**

		£	s.	d.
B.S. 1400 P.B.1. (A.I.D. released)	,,	—		
B.S. 1400 L.P.B.1	,,	—		

**Average prices for the last week-end.*

Phosphor Copper

		£	s.	d.
10%	ton	254	0	0
15%	,,	256	0	0

Phosphor Tin

		£	s.	d.
5%	,,	—		

Silicon Bronze

		£	s.	d.
BSS 1400-SB1	,,	245	0	0

Solder, soft, BSS 219

		£	s.	d.
Grade C Tinmans	,,	369	0	0
Grade D Plumbers	,,	296	5	0
Grade M	,,	404	5	0

Solder, Brazing, BSS 1845

		£	s.	d.
Type 8 (Granulated)	lb.	—		
Type 9 ,,	,,	—		

Zinc Alloys

		£	s.	d.
B.S.S.1004 Alloy A	ton	121	16	3
B.S.S.1004 Alloy B	,,	125	16	3
Sodium-Zinc	lb.		2	7½

Semi-Fabricated Products

Prices vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium

		£	s.	d.
Sheet 10 S.W.G.	lb.		2	8½
Sheet 18 S.W.G.	,,		2	10½
Sheet 24 S.W.G.	,,		3	1½
Strip 10 S.W.G.	,,		2	8½
Strip 18 S.W.G.	,,		2	9½
Strip 24 S.W.G.	,,		2	11
Circles 22 S.W.G.	,,		3	2½
Circles 18 S.W.G.	,,		3	1½
Circles 12 S.W.G.	,,		3	0½
Plate as rolled	,,		2	8
Sections	,,		3	2
Wire 10 S.W.G.	,,		2	11½
Tubes 1 in. o.d. 16 S.W.G.	,,		4	1

Aluminium Alloys

		£	s.	d.
BS1470. HS10W.				
Sheet 10 S.W.G.	,,		3	1
Sheet 18 S.W.G.	,,		3	3½
Sheet 24 S.W.G.	,,		3	11
Strip 10 S.W.G.	,,		3	1
Strip 18 S.W.G.	,,		3	2½
Strip 24 S.W.G.	,,		3	10½
BS1477. HP30M.				
Plate as rolled	,,		2	11
BS1470. HC15WP.				
Sheet 10 S.W.G.	,,		3	9½
Sheet 18 S.W.G.	,,		4	2
Sheet 24 S.W.G.	,,		5	0½
Strip 10 S.W.G.	,,		3	10½
Strip 18 S.W.G.	,,		4	2
Strip 24 S.W.G.	,,		4	9½
BS1477. HPC15WP.				
Plate heat treated	,,		6	3½
BS1475. HG10W.				
Wire 10 S.W.G.	,,		3	10½
BS1471. HT10WP.				
Tubes 1 in. o.d. 16 S.W.G.	,,		5	0½
BS1476. HE10WP.				
Sections	,,		3	1½

Brass

		£	s.	d.
Tubes	,,		1	10⅜
Brazed Tubes	,,		3	0¼
Drawn Strip Sections	,,		3	0⅞
Sheet	ton	202	15	0
Strip	,,	202	15	0
Extruded Bar	lb.		2	0¾
Extruded Bar (Pure Metal Basis)	,,	—		

Brass

		£	s.	d.
Condenser Plate (Yellow Metal)	ton	194	0	0
Condenser Plate (Naval Brass)	,,	205	0	0
Wire	lb.		2	8

Beryllium Copper

		£	s.	d.
Strip	,,	1	4	11
Rod	,,	1	1	6
Wire	,,	1	4	9

Copper

		£	s.	d.
Tubes	lb.		2	2¾
Sheet	ton	261	15	0
Strip	,,	261	15	0
Plain Plates	,,		—	
Locomotive Rods	,,		—	
H.C. Wire	,,	285	5	0

Cupro Nickel

		£	s.	d.
Tubes 70/30	lb.		3	6⅞

Lead

		£	s.	d.
Pipes (London)	ton	111	5	0
Sheet (London)	,,	109	0	0
Tellurium Lead	,,	£6 extra		

Nickel Silver

		£	s.	d.
Sheet and Strip 7%	lb.		3	8½
Wire 10%	,,		4	3¼

Phosphor Bronze

		£	s.	d.
Wire	,,		4	0½

Titanium (1,000 lb. lots)

Billet 4½" to 18" dia.	lb.	54/-	55/-
Rod ¼" to 4" dia.	,,	95/-	62/-
Wire ·036"-·232" dia.	,,	167/-	110/-
Strip ·003" to ·048"	,,	200/-	75/-
Sheet 8' × 2'. 20 gauge	,,	85/-	
Tube, representative average gauge	,,	300/-	
Extrusions	,,	105/-	

Zinc

		£	s.	d.
Sheet	ton	122	10	0
Strip	,,	nom.		

Domestic and Foreign

Merchants' average buying prices delivered, per ton, 13/10/59.

Aluminium

	£
New Cuttings	150
Old Rolled	134
Segregated Turnings	104

Brass

	£
Cuttings	162
Rod Ends	149
Heavy Yellow	123
Light	117
Rolled	153
Collected Scrap	118
Turnings	142

Copper

	£
Wire	208
Firebox, cut up	200
Heavy	195
Light	188
Cuttings	208
Turnings	190
Braziery	158

Gunmetal

	£
Gear Wheels	172
Admiralty	172
Commercial	158
Turnings	153

Lead

	£
Scrap	60

Nickel

	£
Cuttings	—
Anodes	550

Phosphor Bronze

	£
Scrap	158
Turnings	153

Zinc

	£
Remelted	78
Cuttings	63
Old Zinc	42

New Companies

The particulars of companies recently registered are quoted from the daily register compiled by Jordan and Sons Limited, Company Registration Agents, Chancery Lane, W.C.2.

Wragg Bros. (Aluminium Equipment) Limited (637484), 13 Long Moor, Cheshunt, Herts. Registered September 18, 1959. Nominal capital, £2,000 in £1 shares. Directors: Edward Wragg, Richard Wragg and Wm. Wragg.

Doric Metal Productions Limited (637602), 47 Newhall Hill, Birmingham. Registered September 22, 1959. Nominal capital, £5,000 in £1 shares. To take over business of manufacturers of metal pressings carried on as "Doric Productions Co." at Birmingham, etc. Permanent directors: Arthur V. Hawkins and Barry R. Hawkins.

T.C.W. (Argon) Welders Limited (637735), North Dock, Roker, Sunderland. Registered September 23, 1959. Nominal capital, £1,000 in £1 shares. Directors: Charles W. Dorkin and Tom Middleton.

Reeve Polishing and Plating Company Limited (637814), 85-87 Clifford Street, Lozells, Birmingham. Registered September 24, 1959. Nominal capital, £10,000 in £1 shares. Directors: George J. Flynn, George E. Flynn and Wm. H. Badger.

Stelloy Company Limited (637827), 22 Waterloo Road, Wolverhampton. Registered September 24, 1959. To carry on business of manufacturers of and dealers in steel and alloy roofing and roofing, insulating, non-conducting and anti-fouling compositions, etc. Nominal capital, £1,000 in £1 shares. Permanent directors: Walter H. Hamer, Alan Jeavons and James Dawes.

Trade Publications

Foundry Equipment.—The Incandescent Heat Company Ltd., Cornwall Road, Smethwick, Birmingham.

An additional foundry leaflet just issued by this company deals with ladles and receivers produced by the company. Several types of ladles are described and illustrated in colour, while various types of receivers are also included. Some pages are devoted to lift-out, bale-out or tilting crucible furnaces for non-ferrous foundries which are manufactured by the company. These furnaces are fired by oil or gas.

Turret Punch Presses.—Dowding and Doll Ltd., 346 Kensington High Street, London, W.14.

A comprehensive brochure describing their complete range of British Wiedemann turret punch presses has been produced by this company. The short production times, of which typical examples are given in the new brochure, should be of special interest to all concerned with the production of pierced work, such as chassis for electronic apparatus, aircraft, and electrical panels, where runs are comparatively short and modifications frequently made. In addition to technical data the brochure contains a number of photographs of machines.

Foundry Practice. — Foundry Services Limited. Long Acre, Nechells, Birmingham 7.

The latest available issue of this journal contains some notes on gross defects in brass pressure die-castings, together with statistical data and some illustrations. An interesting occupant on the two centre pages is a "Report on the introductory remarks by director A. Hope to a party of visiting foundrymen, November 31st, 1978".

Mechanical Seals. — Flexibox Limited, Nash Road, Trafford Park, Manchester 17.

This company has produced a new comprehensive mechanical seal catalogue in which is described the full range of Flexibox balanced and unbalanced mechanical gland seals for all types of rotary shaft equipment—pumps, mixers, agitators, compressors and the like. The catalogue has been primarily designed to provide users of such seals with a rapid means of selecting the correct type and size of seal for any given application. To this end, tables of essential dimensions, operating limits, power absorption and frictional heat development monograms and details of P.V. ratings have been included. In addition, a recommended materials specification for seal components is given for more than 350 fluids.

Moisture Control.—Mobil Oil Company Limited. Caxton House, Westminster, London, S.W.1.

A technical bulletin described two new products, Mobil Sorbead R. and Mobil Sorbead W., which have been formulated to effect moisture control in surroundings where the presence of water vapour may cause difficulties. Mobil Sorbead R. is recommended for the widest use, while Mobil Sorbead W. has been developed as a specially resistant bead for use where the presence of liquid water has to be taken into account. The introduction of these two new products in the U.K. has only been made after tests and observations carried out during the past 12 months.

Welding Controls. — Radiovisor Patent Ltd. (Welding Control Division) Stanhope Works, High Path, London, S.W.19.

An illustrated leaflet has been produced describing new Radiovisor resistance welding controls. This company is the sole licensee and manufacturer in the U.K. and Europe of the complete range of resistance weld timers designed by the Robotron Corporation of Detroit, U.S.A.

Laboratory Chemicals. — Griffin and George Ltd., Ealing Road, Alperton, Wembley, Middx.

An 84-page publication containing their current price list of laboratory chemicals has just been distributed by this company. It contains a complete list of general chemicals, AnalaR and microanalytical (M.A.R.) reagents, and many pages devoted to microscopical stains, reagents for water analysis and other specialized items.

Scrap Metal Prices

The figures in brackets give the English equivalents in £1 per ton:—

West Germany (D-marks per 100 kilos):

Used copper wire ..	(£205.17.6)	235
Heavy copper	(£201.10.0)	230
Light copper	(£170.17.6)	195
Heavy brass	(£118.5.0)	135
Light brass	(£91.17.6)	105
Soft lead scrap	(£56.0.0)	64
Zinc scrap	(£38.12.6)	44
Used aluminium unsorted	(£105.2.6)	120

France (francs per kilo):

Electrolytic copper scrap	(£191.2.6)	255
Heavy copper	(£191.2.6)	255
No. 1 copper wire ..	(£176.2.6)	235
Brass rod ends......	(£127.12.6)	170
Zinc castings	(£51.0.0)	68
Lead	(£69.0.0)	92
Aluminium	(£129.12.6)	173

Italy (lire per kilo):

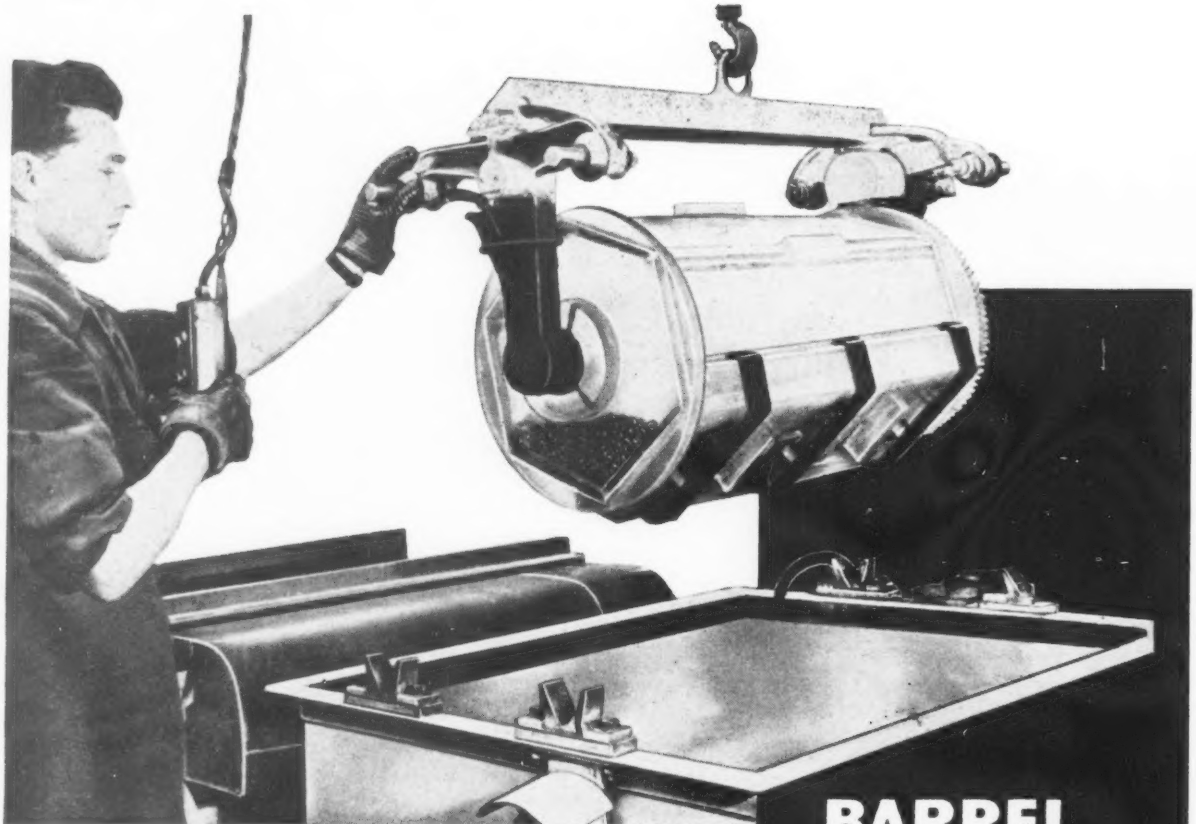
Aluminium soft sheet clippings (new) ..	(£200.15.0)	340
Aluminium copper alloy	(£135.17.6)	240
Lead, soft, first quality	(£79.0.0)	134
Lead, battery plates	(£44.5.0)	75
Copper, first grade	(£221.5.0)	375
Copper, second grade	(£209.10.0)	355
Bronze, first quality machinery	(£203.2.6)	345
Bronze, commercial gunmetal	(£174.10.0)	295
Brass, heavy........	(£147.12.6)	250
Brass, light	(£237.17.6)	225
Brass, bar turnings ..	(£135.17.6)	230
New zinc sheet clippings	(£65.0.0)	110
Old zinc	(£50.2.6)	85

THE STOCK EXCHANGE

Boom Conditions In Industrials Particularly Steels Following Election

ISSUED CAPITAL ●	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 12 OCTOBER +RISE — FALL		DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1959 HIGH	1959 LOW	1958 HIGH	1958 LOW
£	£				Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	27/9	+9d.	9	9	6 9 9	27/9	23/3	24/9	17/6
400,000	2/–	Anti-Attrition Metal	1/3		4	8½	6 15 0	1/6	1/3	1/9	1/3
41,303,829	Stk. (£1)	Associated Electrical Industries ...	64/3	+3/–	15	15	4 13 6	65/–	54/–	58/9	46/6
1,613,280	1	Birfield	59/6	+1/–	15	15	5 5 9	60/–	46/9	62/4½	46/3
3,196,667	1	Birmid Industries	85/6	+2/9	17½	17½	4 1 9	85/6	72/–	77/6	55/3
5,630,344	Stk. (£1)	Birmingham Small Arms	50/–	+2/9	11	10	4 8 0	50/–	36/1½	39/–	23/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/9		5	5	6 7 0	16/3	15/–	16/1½	14/7½
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	18/7½		6	6	6 8 9	18/10½	17/9	17/4½	16/6
500,000	1	Bolton (Thos.) & Sons	34/6		10	10	5 16 0	34/6	27/6	28/9	24/–
300,000	1	Ditto Pref. 5%	15/–		5	5	6 13 3	15/6	14/–	16/–	15/–
160,000	1	Booth (James) & Co. Cum. Pref. 7%	20/6		7	7	6 16 6	20/6	20/–	20/4½	19/–
1,500,000	Stk. (£1)	British Aluminium Co. Pref. 6% ...	19/9	—9d.	6	6	6 1 6	20/7½	18/9	20/–	18/4½
17,247,070	Stk. (£1)	British Insulated Callender's Cables	57/6	+3/6	12½	12½	4 7 0	59/6	46/3	52/6	38/9
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord. ...	72/6	+6/–	10	10	2 15 3	77/–	49/3	52/–	28/3
1,200,000	Stk. (5/–)	Canning (W.) & Co.	14/10½	+6d.	25 + *2¼C‡	25	4 4 0	16/–	12/3	25/3	19/3
60,484	1/–	Carr (Chas.)	1/7½	—4½d.	12½	25	7 13 9	2/10½	1/3	2/3	1/4¼
555,000	1	Clifford (Chas.) Ltd.	26/3		10	10	7 12 6	27/–	22/6	22/–	16/–
45,000	1	Ditto Cum. Pref. 6%	16/9	—3d.	6	6	7 3 3	17/–	15/3	16/–	15/–
250,000	2/–	Coley Metals	3/–		15	20	10 0 0	4/–	2/10½	4/6	2/6
10,185,696	1	Cons. Zinc Corp.†	63/6	—6d.	15	18¾	4 14 6	69/3	59/–	65/3	41/–
1,509,528	1	Davy & United	96/–	+1/–	30‡	20	3 2 6	98/6	43/1½	87/–	45/9
6,840,000	5/–	Delta Metal	20/6	+3/3	31‡	30	3 15 6	21/–	12/–	25/–	17/7½
5 296,550	Stk. (£1)	Enfield Rolling Mills Ltd.	57/6	+2/9	15	12½	5 4 3	57/6	36/7½	38/–	22/9
750,000	1	Evered & Co.	35/4½		10§	15D	5 13 0	35/9	30/–	30/–	26/–
18,000,000	Stk. (£1)	General Electric Co.	46/–	+6/–	10	10P	4 7 0	46/–	30/–	40/6	29/6
1,500,000	Stk. (10/–)	General Refractories Ltd.	43/3	+3/3	20	20	4 12 6	43/3	31/9	39/3	27/3
401,240	1	Gibbons (Dudley) Ltd.	63/–	—1/4½	16½	15	5 4 9	66/6	63/–	67/6	61/–
750,000	5/–	Glacier Metal Co. Ltd.	8/6	+6d.	11½	11½	6 15 3	9/3	6/7½	8/3	5/–
1,750,000	5/	Glynwed Tubes	23/1½	+1/4½	20¶	20	4 6 6	23/6	16/4½	18/1½	12/10½
5,421,049	10/–	Goodlass Wall & Lead Industries ...	46/6	+5/6	13‖	18D	2 16 0	46/6	28/7½	30/9	17/3
342,195	1	Greenwood & Batley	105/–		30	20	5 14 3	108/3	75/–	57/9	45/–
396,000	5/–	Harrison (B'ham) Ord.	20/9	+1/–	*17½	*15	4 4 3	20/9	14/11¼	15/9	11/6
150,000	1	Ditto Cum. Pref. 7%	19/6		7	7	7 3 6	19/6	19/3	19/9	18/4½
1,075,167	5/–	Heenan Group	12/6	+9d.	10	10‡	4 0 0	12/6	7/6	9/7½	6/9
246,209,422	Stk. (£1)	Imperial Chemical Industries ...	53/9	+7/3	12DZ	10	2 19 6	54/6	33/9	38/–	24/3
34,736,773	Stk. (£1)	Ditto Cum. Pref. 5%	17/1½	+4½d.	5	5	5 16 9	17/10½	16/–	17/1½	16/–
14,584,025	**	International Nickel	169	—3	$2.60	$3.75	2 17 0	187¾	154½	169	132¾
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	15/9	—6d.	5	5	6 7 0	16/3	15/4½	16/9	15/–
6,000,000	1	Ditto Ord.	43/9	+3/9	12D	10	3 13 3	44/3	29/7½	47/–	36/6
600,000	10/–	Keith, Blackman	31/3		17½E	15	4 7 0	31/3	25/–	28/9	15/–
320,000	4/–	London Aluminium	6/7½	+1½d.	10	10	6 0 9	6/9	5/3	6/–	3/–
765,012	1	McKechnie Brothers Ord.	46/–		15	15	6 10 6	45/–	41/–	45/–	32/–
1,530,024	1	Ditto A Ord.	43/–		15	15	6 19 6	43/6	38/9	45/–	30/–
1,108,268	5/–	Manganese Bronze & Brass	16/–	+6d.	20⅝	20	6 10 3	16/3	13/9	14/1½	8/9
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–		7½	7½	7 10 0	—	—	6/3	5/6
13,098,855	Stk. (£1)	Metal Box	71/6	+7/9	11	11	3 1 6	80/–	44/7½	73/3	40/6
415,760	Stk. (2/–)	Metal Traders	10/9		50	50	9 6 0	12/3	8/4½	9/–	6/3
160,000	1	Mint (The) Birmingham	28/–		10	10	7 2 9	28/–	22/–	22/9	19/–
80,000	5	Ditto Pref. 6%	80/–		6	6	7 10 0	75/6	69/–	83/6	69/–
3,705,670	Stk. (£1)	Morgan Crucible A	58/6	+1/–	10ϕ	10	3 8 6	58/6	43/6	45/–	34/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/6		5½	5½	6 5 9	18/6	17/6	18/–	17/–
2,200,000	Stk. (£1)	Murex	55/9	+3/6	15	17½	5 7 9	58/–	41/–	58/9	46/–
468,000	5/–	Ratcliffs (Great Bridge)	12/–		10R	10	3 2 6	12/–	9/6	11/1½	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	41/–		25	20	6 2 0	41/–	27/9	27/3	24/6
1,365,000	Stk. (5/–)	Serck	26/6	+2/6	15	17½	2 17 9	26/7½	18/–	18/7½	11/–
6,698,586	Stk. (£1)	Stone-Platt Industries	53/6	+2/6	15	15	5 12 3	53/6	42/6	45/6	22/6
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	17/9		5½	5½	6 4 0	18/–	15/10½	16/3	12/7½
18,255,218	Stk. (£1)	Tube Investments Ord.	104/6	+6/6	17½	15	3 7 0	113/–	72/–	86/–	48/4½
41,000,000	Stk. (£1)	Vickers	30/3	+1/9	10	10	6 12 3	37/–	27/4½	36/3	28/9
750,000	Stk. (£1)	Ditto Pref. 5%	15/–		5	5	6 13 9	15/0¾	14/3	15/9	14/3
6,863,807	Stk. (£1)	Ditto Pref. 5% tax free	21/3		*5	*5	6 19 0A	22/7½	20/6	23/–	21/3
2,200,000	1	Ward (Thos. W.), Ord.	115/–	+14/–	20	15	3 9 6	115/–	83/–	87/3	70/9
2,666,034	Stk. (£1)	Westinghouse Brake	53/–	+4/–	10	10	3 15 6	53/–	39/9	46/6	32/6
225,000	2/–	Wolverhampton Die-Casting ...	10/–	+1½d.	30	25	6 0 0	10/6	8/8¼	10/1½	7/–
591,000	5/–	Wolverhampton Metal	29/4½	+1/1½	27½	27½	4 13 6	32/6	21/6	22/9	14/9
78,465	2/6	Wright, Bindley & Gell	6/7½		20	20	7 11 0	7/6	4/11¼	5/4½	2/9
124,140	1	Ditto Cum. Pref. 6%	13/9		6	6	8 14 9	13/9	12/10½	13/–	11/3
150,000	1/–	Zinc Alloy Rust Proof	3/4½	—1½d.	27	40D	8 0 0	3/9¾	2/9	3/1½	2/7½

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting. **Shares of no Par Value. ‡ and 100% Capitalized issue. ●The figures given relate to the issue quoted in the third column. A Calculated on £7 8 9 gross. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. D and 50% capitalized issue. **C Paid out of Capital Profits.** E and 50% capitalized issue in 7% 2nd Pref. Shares. § And Special distribution of 2½% free of tax. R And 33⅓% capitalized issue in 8% Maximum Ordinary 5/– Stock Units. ¶ Interim since increased from 10% to 12%. ϕ And proposed 40% capitalized issue. Z Interim since increased.



Efco-Udylite

BARREL PLATING EQUIPMENT

Designed for Maximum Output

Special well-proven features are built into EFCO-Udylite fully immersed plating barrels, such as high current carrying electrical contacts and large perforated area. Specification plating is thus achieved at the highest output per barrel, providing economies in labour, floor space and maintenance.

EFCO **ELECTRO-CHEMICAL ENGINEERING CO. LTD.**

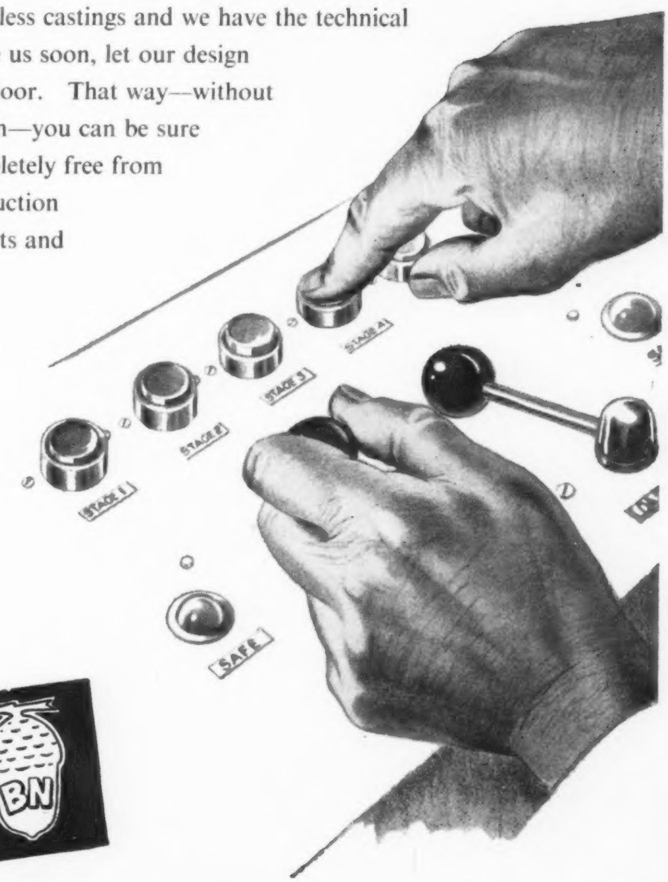
SHEERWATER, WOKING, SURREY. *Telephone WOKING 5222-7*

NRP 2493

ARE YOU

mass producing ?

Better see us about the castings. You'll want a continuous supply of exact, flawless castings and we have the technical teamwork to give it to you. See us soon, let our design engineers in on the ground floor. That way—without departing from your essential specification—you can be sure that the final casting is completely free from hidden structural fault. And when production begins, leave it to our metallurgists and foundry engineers to ensure that the soundness and accuracy of every casting is faithfully maintained.



CASTINGS FROM A FEW OUNCES TO TEN TONS

in phosphor-bronze, gun-metal, aluminium-bronze, manganese-bronze, and light alloys. Specialists in high-tensile aluminium-bronze castings, centrifugal-cast wheel blanks, shell moulded castings, and chill-cast rods and tubes. Continuous cast phosphor-bronze bars up to 12 feet lengths.

BIRSO TRADE MARK BN

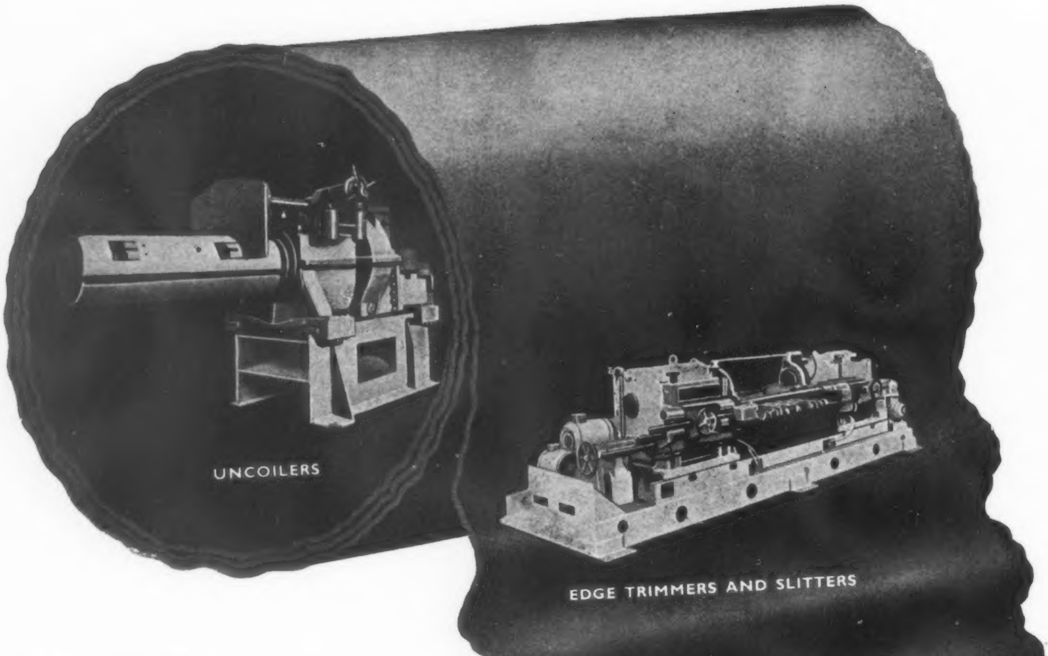
NON-FERROUS CASTINGS

HIGH DUTY IRON CASTINGS · PRECISION MACHINED BUSHES & BEARINGS

T. M. BIRKETT, BILLINGTON & NEWTON LTD

HANLEY AND LONGPORT, STOKE-ON-TRENT, ENGLAND

Head Office: HANLEY, Phone: Stoke-on-Trent 22184/5/6/7. LONGPORT, Phone: Newcastle, Staffs 51433/4.



shaping up to requirements

These machines are examples from the extensive range of equipment built by The Head Wrightson Machine Company for steel and non-ferrous metal production and fabrication. In these fields, Head Wrightson machines are effecting significant economies and increased production. Our engineering and manufacturing resources are always available to deal with your special requirements.

THE HEAD WRIGHTSON MACHINE CO LTD

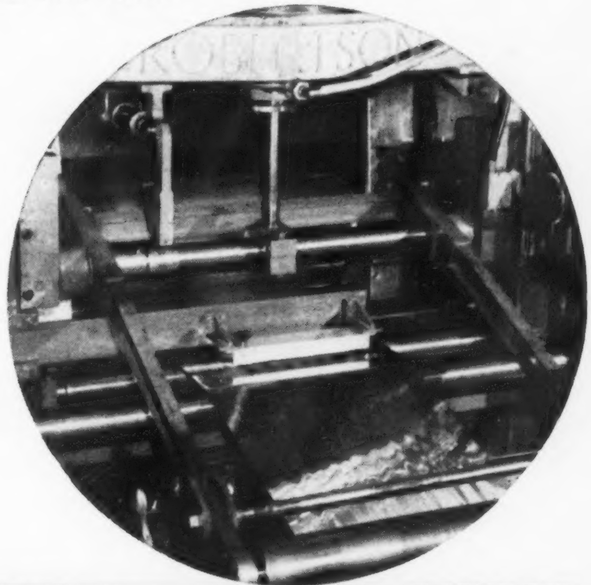
COMMERCIAL STREET · MIDDLESBROUGH

LONDON JOHANNESBURG · TORONTO · SYDNEY · CALCUTTA

Baldwin Atomat Nucleonic Thickness Gauges

ACCURATE, CONTINUOUS, NON-CONTACT INSPECTION

SAVES MATERIAL, LABOUR AND TIME!



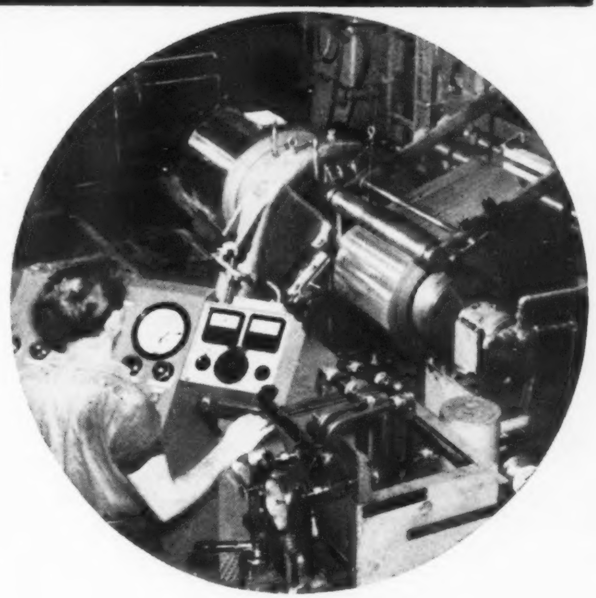
The Atomat Principle

RAY SOURCE
MATERIAL
RAY DETECTOR
Amount of rays passing through material indicates thickness or weight per unit area.

That's the very basic explanation of the Atomat principle. There are three main gauges; the Atomat Cold Strip Gauge, the Hot Strip Gauge and the Beta Gauge.
In addition there are special purpose variations, made to meet the requirements of many different industries.

HERE'S WHAT AN ATOMAT GAUGE CAN OFFER YOU

- **Time and material saving both in production and setting up**
- **High accuracy**
- **Calibration in your usual units of measurement**
- **Continuous readings for materials in constant production**
- **Auto standardisation and control if you require**
- **Minimum maintenance**



Baldwin Atomats are already boosting production and cutting costs in the paper, metal rolling, rubber and plastics industries. Highly successful applications also include the measuring of selenium on aluminium, coatings of paint and lacquers, density of wood chips, coatings of grit on abrasive papers and padding and resin impregnation in the textile industry. But the potential of Baldwin Atomat Nucleonic Gauges has hardly been tapped.
Is there a place for them in your plant?

INSTRUMENT DIVISION

Send for the Baldwin Brochure M.I. 124
It gives full information on Atomat Gauges clearly and concisely.

BALDWIN INDUSTRIAL CONTROLS

Baldwin Instrument Company Limited Dartford Kent A Harper Group Company

DARTFORD 6411 & 2948 Cables & Telex: Baldwin, Dartford

B22


FOR Diecastings as strong as steel
ALUMINIUM BRONZE CO., LTD.
Wallows Lane · Walsall · Staffs.
Telephone: WALSALL 2108 (3 lines)
Telegrams: "ABCO · WALSALL"


APDP
DIE CASTINGS
for all Trades
Die Castings illustrated are examples of our everyday production. They require little finishing before use and therefore effect a considerable REDUCTION in production costs, and an INCREASE in output.
We Specialise in the design of high pressure die castings in MAZAC zinc base alloy manufactured under B.S.I. Scheme and in alloys of aluminium and brass.
CERTIFIED ZINC ALLOY ZADCA DIE CASTERS
ALLOY PRESSURE DIE PRODUCTS LTD
BOWKER STREET · WILLENHALL · STAFFS ·
Telephone WOLVERHAMPTON 21271-2 & 25588

Rate: Advertisements set in run-on style 4d. per word, minimum 4/–. Semi-displayed announcements are charged at 22/6 per inch depth. Box Numbers: add 5 words, plus 1/– for registration and forwarding replies. "Copy" accepted at London Office up to 1st post on each Friday for the following Friday's issue.

METAL INDUSTRY
CLASSIFIED ADVERTISEMENTS

Trade Discounts: Details upon application to "Metal Industry," Dorset House, Stamford Street, London, S.E.1. Remittances payable to Iliffe & Sons Ltd. The proprietors retain the right to refuse or withdraw "copy" at their discretion and accept no responsibility for matters arising from clerical or printers' errors.

APPOINTMENTS VACANT

THE GLACIER METAL CO. LTD.
METALLURGIST.

A VACANCY exists in our Central Research Organization for a Metallurgist, to manage a metallurgical laboratory (two subordinates) and prepare metallurgical examinations of bearing failures for research purposes, and to assist Sales Engineers advising customers on bearing applications.

REQUIREMENTS: at least 25 years old. Degree in metallurgy or A.I.M., experience in running a metallurgical laboratory, particularly in engineering. Salary bracket: £900 to £1,350, starting to £1,200. Opportunity to advance on research side or to sales work.

SEND brief, relevant picture of yourself to Personnel Manager (Ref. 2155), Glacier Metal Co., Alperton, Wembley, Middlesex. [7886

HUNTS. EDUCATION COMMITTEE.
FLETTON SECONDARY MODERN SCHOOL (PETERBOROUGH).

APPLICATIONS are invited from suitably qualified teachers for appointment as Metalwork Master at this newly re-organized school of about 700 pupils. Forms of application may be obtained from the undersigned and should be returned, duly completed, as soon as possible.
IAN C. CURREY.
Director of Education.
Gazeley House,
Huntingdon. [7885

BUSINESS & PROPERTY

CLAPHAM: 14,600 sq. ft. Warehouse Building, strongly constructed on Ground, First and Second Floors. Central Heating to part. Two-floor office building. Large yard of 11,000 sq. ft. enclosed by brick walls and providing convenient loading. Freehold £36,000. Chamberlain & Willows, 23 Moorgate, E.C.2. (Met. 8001) [7884

CAPACITY AVAILABLE

SHEET Metal Work, Metal Spinning, Deep Drawn Pressings, Stamping Press capacity 200 tons. Max. draw 15". Enquiries or specifications to Wades (Halifax) Ltd., Arden Works, Fenton Road, Halifax. [0019

KELLERING and Cam Profiling Capacity up to 8 ft. × 6 ft., or 6 ft. diameter.
ARMYTAGE BROS. (KNOTTINGLEY) Ltd., The Foundry, Knottingley, Yorkshire. Tel. Knottingley 2743/4. [0001

PRESSURE Casting Foundries. Pressure Dies designed, manufactured. Capacity immediate. R. E. Ormerod Ltd., Ednall Lane, Bromsgrove, Worcs. [7864

ALUMINIUM Foundries. Gravity Dies Designed, Manufactured and Proved. Capacity immediate. R. E. Ormerod Ltd., Ednall Lane, Bromsgrove, Worcs. [7865

ALUMINIUM Fabrications. General Sheet Metal Work, Metal Spinning, Welding. High class work. Immediate capacity. Wragg Bros. (Aluminium Equipment) Ltd., Albury Lodge, Turners Hill, Cheshunt, Herts. [7880

HEAT TREATMENTS

HEAT Treatment. A.I.D. Approved, all wrought and cast Light Alloys. Large sizes a speciality. Electro Heat Treatments Ltd., Bull Lane, West Bromwich. Phone Wes 0756. [0005

PLANT WANTED

DIE-CASTING Machines Wanted. E.M.B.12 and others. Box 5400, c/o Metal Industry. [7887

CHIEF BUYER

required for **NON-FERROUS AND LIGHT ALLOY SCRAP** by old established manufacturing company in the Birmingham area.

Must be engaged in the trade at present.

Age 30–40 years.

Salary £2,000–£3,000 according to age and experience.

For further details please apply:

Birmingham Productivity Association Technical Advisory Service Limited,

95 NEW STREET, BIRMINGHAM, 2.

Tel.: MID. 0912.
Quoting Ref. 868/CB.

SCRAP METAL (SALE & WANTED)

B. J. PERRY & CO. LTD.
Exchange Buildings, Birmingham, 2, for Phosphor Bronze, Swarf and Scrap and all Non-Ferrous Metals.
Tel.: Midland 5986-7. [0013

URGENTLY REQUIRED
ZINC BASE ALLOY SCRAP
clean or contaminated
TURNINGS AND SKIMMINGS.
MITCHAM SMELTERS LTD.
REDHOUSE ROAD,
MITCHAM ROAD,
CROYDON, SURREY. [0008

NICKEL and High Nickel Content Scrap wanted. "Nimonics", "Inconel", "Monel", etc. Offer for best prices to Nicholson & Rhodes Ltd., Princess St., Sheffield, 4. Phone 27491. [0011

TIME RECORDERS

FACTORY Time Recorders. Rental Service. Phone Hop. 2239. Time Recorder Supply and Maintenance Co. Ltd., 157-159 Borough High Street, S.E.1. [0014

BOOKS

HANDBOOK of Industrial Electroplating. Second Edition. By E. A. Ollard, A.R.C.S., F.R.I.C., F.I.M., and E. B. Smith. Facts, figures and formulae for all who design, erect, maintain or operate electrodeposition plant, and for laboratory workers who deal with plating solutions. Includes sections on water and drainage, purification of solutions, safety precautions and ventilation in plating shops, and the special problems of costing in such shops. 35s. net from all booksellers. By post 36s. 5d. from Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

BOOKS

RESISTANCE Welding in Mass Production. By A. J. Hipperson, B.Sc.(Eng.), A.M.Inst.W., and T. Watson, M.Inst.W. The ground covered by this book ranges from the first principles of each process to its scientific application in mass production. Particular reference is made to design and production requirements. 21s. net from all booksellers, 22s. 1d. by post from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

PRODUCTION Engineering: Practical Methods of Production Planning and Control. By J. S. Murphy, A.I.I.A. This practical book deals with factory organization, each separate item or function being discussed in the order in which it arises in practice. The book provides experienced production engineers with an opportunity to compare different methods. Price 12s. 6d. net. By post 13s. 5d. from all booksellers, or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

METALS and Alloys. Fifth Edition. This book contains approximately 4,600 compositions of non-ferrous alloy. It is mainly a list of alloys having definite names, including proprietary alloys, and it is indispensable to users of non-ferrous metals and alloys in any industry. 15s. net from all booksellers. By post 16s. from Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

INDUSTRIAL Brazing. By H. R. Brooker and E. V. Beatson, B.Sc.(Eng.), A.M.I.E.E. The first full-length study of this subject. Covers in detail all modern brazing methods, including torch, furnace, high-frequency induction, resistance, salt bath and dip, with chapters on the special techniques necessary for aluminium, stainless steels, beryllium, copper, cemented carbides and vacuum tube construction. 35s. net from all booksellers. By post 36s. 6d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

OXYGEN Cutting: A Comprehensive Study of Modern Practice in Manual and Machine Cutting. By E. Seymour Semper, M.I.Mech.E., M.Inst.W. Written to assist engineers concerned with cutting and shaping material, this book describes many of the machines designed for various applications of oxygen cutting to template with multiple heads and also the actual methods of operation. Price 10s. 6d. net. By post 11s. 4d. From all booksellers or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

GAS Welding and Cutting: A Practical Guide to the Best Techniques. By C. G. Bainbridge, M.I.Mech.E., M.Inst.W. A comprehensive text-book providing practical information on almost the whole range of available gas welding and cutting equipment, methods and processes. Invaluable to the practical welder as well as to those responsible for gas welding and cutting operations involved in the fabrication and repair of industrial equipment. Price 15s. net. By post 16s. 0d. From all booksellers or from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

MATERIAL Handling in Works Stores. 2nd Edition. By L. J. Hoefkens. Shows how the use of fork-lift trucks and pallets in industrial stores can increase production, utilize floor space more effectively, help control of movement and reduce costs. Includes a description of a system actually operated in a modern factory. 18s. 0d. net from all booksellers. By post 19s. 0d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

STEELS in Modern Industry. A Comprehensive Survey by 29 Specialist Contributors. General Editor W. E. Benbow. An invaluable guide for engineers, designers and draughtsmen; it specifies the steels best used in various engineering applications (bearing in mind the present need for economy), describes their general and special properties and characteristics, and how they may be surface finished for anti-corrosive and other purposes. 42s. net from all booksellers. By post 43s. 9d. from The Publishing Dept., Dorset House, Stamford Street, London, S.E.1.

INDEX TO ADVERTISEMENTS

Printed in Great Britain by James Cond Ltd., Charlotte Street, Birmingham, 3. Published by Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.